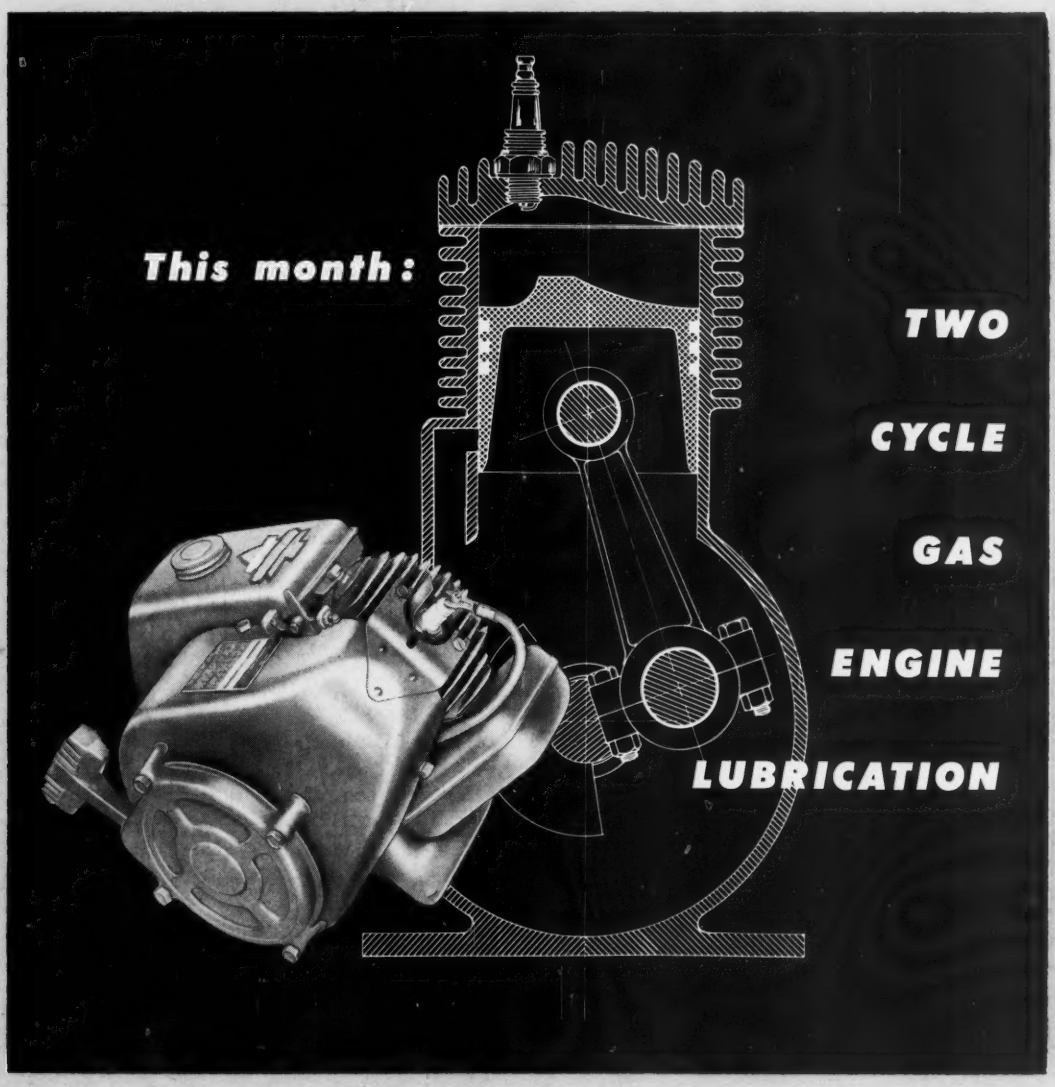
Vol. 15, No. 11 November, 1959

LUBRICATION ENGINEERING

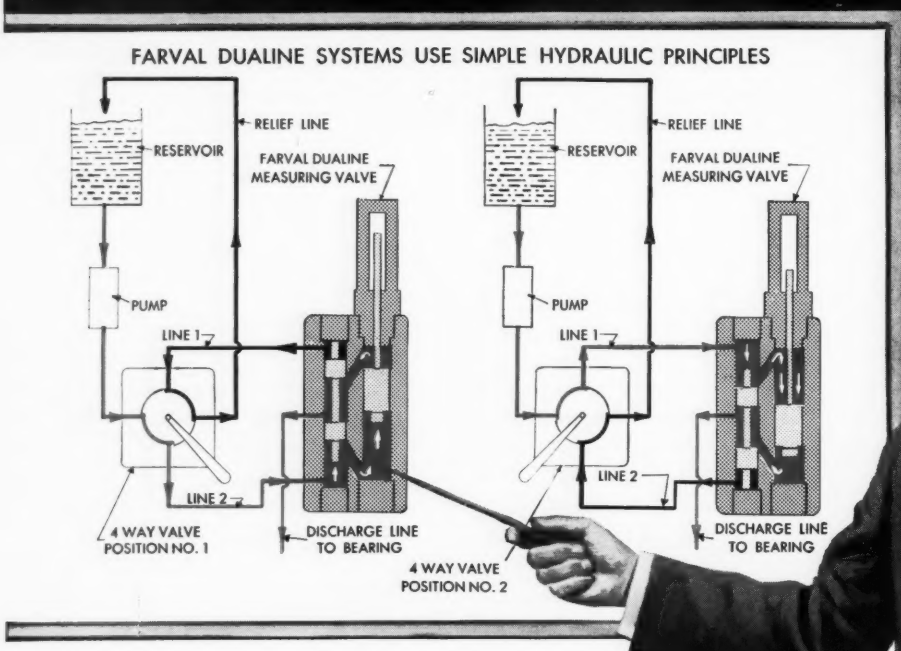
DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

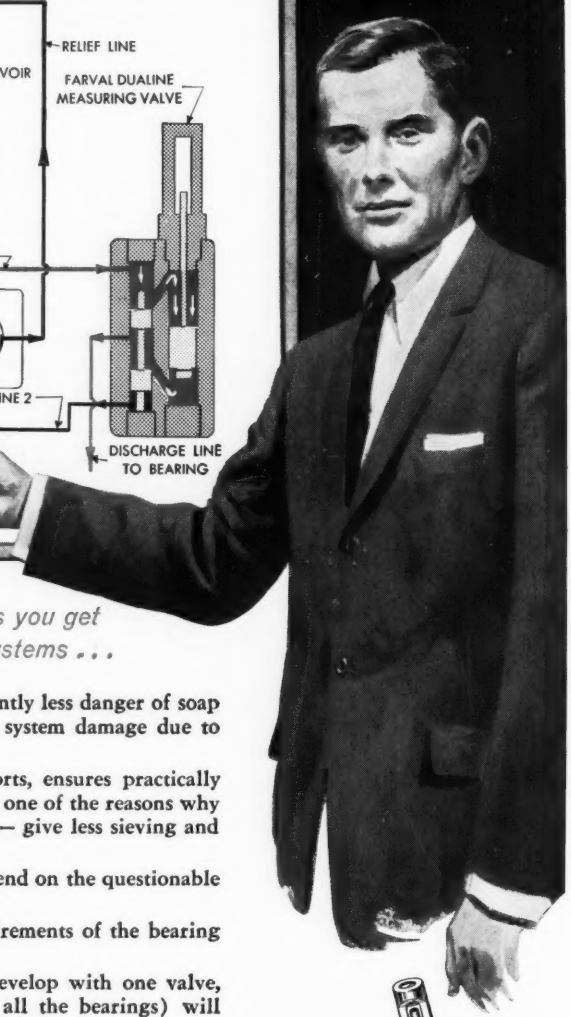


JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

FARVAL
—Studies in Centralized Lubrication
No. 246

"For positive lubrication of large, medium and heavy-duty installations . . . it's a Farval Dualine System!"





With Farval Dualine centralized lubricating systems you get the following distinct advantages over other type systems . . .

(a) Much lower operating pressures with consequently less danger of soap separation on grease systems. Also, less danger of system damage due to high lubricant pressures.

(b) Large lubricant passages with no pinhole ports, ensures practically full pump pressure for every metering valve. This is one of the reasons why Farval Dualine systems operate on lower pressures — give less sieving and working of lubricants.

(c) Positive indication at each bearing — does not have to depend on the questionable action of a single indicator at the pump.

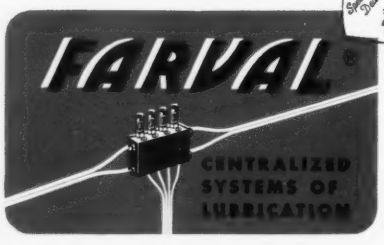
(d) Each metering valve individually adjustable for the requirements of the bearing it serves.

(e) Independent metering valve operation. Should trouble develop with one valve, the system will continue to operate. Only one bearing (not all the bearings) will require hand lubrication until trouble is corrected.

(f) True lubricant metering. Quantity of lubricant delivered to one bearing is not dependent on any other valve in the system.

(g) Much easier to spot and correct trouble.

Check with your Farval Representative and see how these versatile systems can improve production operations — reduce costs. Or write for free Bulletin 26-T containing complete engineering information on Farval Dualine systems. The Farval Corporation, 3267 East 80th Street, Cleveland 4, Ohio.



Affiliate of The Cleveland Worm & Gear Company
A subsidiary of Eaton Manufacturing Company

Volume 15, No. 11
November, 1959

Lubrication Engineering

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

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Army Approves Fire Extinguisher

The U. S. Army's Corps of Engineers has approved a small, hand-held fire extinguisher that uses less than three pounds of a Du Pont brominated compound to do the same fire-fighting job on electrical and flammable liquid blazes that would require considerably larger quantities of the agents now in use.

This approval opened the way for army supply depots to procure the new, safer and more effective portable extinguishers to replace carbon tetrachloride and other types of extinguishers in all mobile vehicles and ground installations of the Army. Specifications are based upon exhaustive equipment tests conducted by the Army Engineers at their Fort Belvoir, Va., Research and Development Laboratories and in the Du Pont Company's Laboratory.

Nitrogen is used as a pressurizing agent for Du Pont's Freon-13B1 monobromotrifluoromethane in the new extinguishers, providing an internal pressure of 400 pounds per square inch gauge at 68 F. That dispensing pressure is sufficient to provide operability at temperatures as low as minus 80 F. Army Engineers' specification for the new extinguisher require that it not only be operable between minus 65 F and 125 F, but also prescribe the size of fires which the extinguisher must be capable of quelling.

MoS_2 Tested for Radiation Harm

A test recently conducted on Molysulfide (MoS_2) provides the first statistical evidence that lubricating properties of this material are not impaired by radiation. This was reported by E. E. Smith, Manager of Climax Molybdenum Company's Chemical Division.

Says Smith: "Data compiled from this research substantiates conclusions up until now based only on general observation of atomic energy installations." He points out that MoS_2 lubricants have been used successfully to solve problems on nuclear reactors, but statistics on the extent of Molysulfide's resistance to radiation were never before compiled.

In the Climax sponsored research, press fit tests were employed to measure the coefficient of friction for both radiated and non-radiated samples of micro-size Molysulfide. Exposed samples registered a coefficient of friction of .057 in comparison to .056 for those unexposed. Samples used were radiated to 10^7 roentgens by Southwest Research Institute, San Antonio, Texas. Alpha Molykote Corporation, Stamford, Connecticut, conducted the press fit trials and examinations.

Fair Trade No Cure For Marketing Ills

Shell Oil Company's marketing vice-president said today that fair trade has been tried and found wanting as a cure for oil marketers' problems.

J. G. Jordan, in a talk titled "Has Fair Trade A Fair Future?" before the Ohio Petroleum Marketers' Association, said he does not believe fair trade can give more than very short term relief.

He gave four reasons for doubts about its chance of success:

1. The retail side of oil marketing is too big and too highly complicated by divergent interests to permit effective administration and enforcement.

2. In major markets, where fair trade might be useful, important segments do not accept it.

3. Fair trade can seriously damage the status of branded products, perhaps even lead to their liquidation.

4. Fair trade could be a step toward more rigid legislative controls. "What happens when some suppliers fair trade in a given market and others do not?" Jordan asked, "any supplier observing the fair trade price invites non-fair-traders to declare open season on his dealers and their volume."

"How about suppliers who run two ways at once and sell through branded outlets and to independents? They have

(*Cont. on p. 468*)

NORTHERN NITRALLOY PUMPS
Lube oil, seal oil and fuel oil pumps for compressors and engines
SEE OUR CATALOG IN SWEET'S
OR WRITE FOR COPY
Complete range in pump sizes from ¼ GPM to 146 GPM. Pressures to 2000 PSI. Proven in thousands of installations and backed by 50 years of engineering and production experience, Northern Steel Block Nitralloy Rotary Gear Pumps are unexcelled for precision manufacture, accurate assembly and dependable, long life operation. Write for free catalog and engineering data.
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NEW PRODUCTS

The Society will not be responsible for the accuracy of statements made in this column. Any reference to proprietary products does not imply an endorsement of such products by the Society.

NON-CHATTERING RELIEF VALVE

A new non-chattering relief valve for liquid service has been announced by J. E. Lonergan Co., Philadelphia, Pa. The new line is called the Lonergan Hydro-Valve. Hydro-Valve is reported to be stable and non-chattering and to provide full-rated capacity in liquid service. It will not drum, chatter, or hammer on any application, either by-pass or emergency relief. Materials handled in test installations over the past three years have included water, fuel and lube oils, and hazardous, flammable liquids. This Valve is available with a bellows if necessary to keep working parts away from contaminants, and corrosive or viscous fluids. Because chatter and its associated bellows flexing action is eliminated, bellows life is greatly extended. The Hydro-Valve line has been primarily used by the process industries. It is, however, available for use in power plants and marine applications. Further details may be obtained by writing the advertising department, J. E. Lonergan Co., 211 Race Street, Philadelphia, Pa.

OIL CONDITION INDICATOR

The Gerin Corporation of Avon, N. J., has announced a new Model of its Oil Condition Indicating Meter which serves all engines—gas, gasoline, and diesel. Although modestly priced, Model DG takes the place of Model D which was used for diesels, and Model G which was used for gasoline engines. The indicator is an accurate gauge type meter which, in the lubricating system of any engine, reveals at a glance the condition of the engine oil, with respect to whether it is time to change oil or filter, and detects hidden engine defects that affect the oil. This meter not only warns promptly when the oil is going bad, it also shows-up any engine that is spoiling the oil by fuel or water leakage and other conditions. The meter responds, exclusively, to changes in the oil due to contamination by dilution, water, running on dead filters, etc., because winter or summer, it is not affected by variations in crankcase temperature. Model DG meter is easily read whether the engine is running or stopped. This convenience permits a man checking the dipstick level or inspecting the engine, to also tell at a glance the condition of the oil.

METALLIC O-RING RETAINER ASSEMBLIES

United Aircraft Products, Inc., has recently incorporated several Metallic O-Rings into one metallic assembly. Several different hole patterns and sizes are designed to match various flange configurations. Metallic O-rings so contained are of the same metal, cross-section O.D. and wall thickness so that the bolt loading factor will be effective across the entire surfaces of the mating flanges. The advantages of this retainer plate are numerous. The metallic O-rings, press-fitted without cross-section distortion, are secured against dropout and possible contamination or loss, and are easily handled during field assignments or retro-fit programs. The openings in the plate function the same as the groove wall does in conventional installations. The metallic O-ring retainer plates can be produced to meet the requirements of most especially designed, two-dimensional junctures, regardless of the number of parts. Additional information can be secured from UAP Engineering Department upon submission of specifications regarding fluids, pressures and temperatures. Write Dept. R, United Metallic O-Rings, Box 1035, Dayton 1, Ohio.

OIL-RESISTANT GLOVES

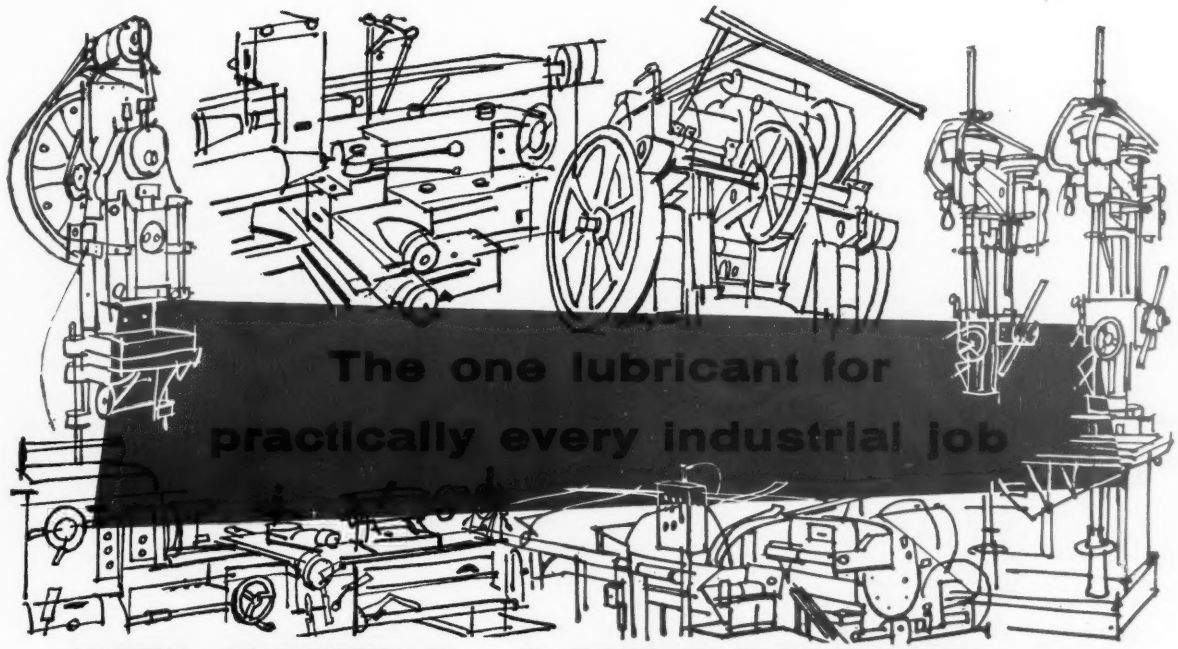
A new line of oil-resistant terry cloth work gloves which retain their dexterity and positive grip when handling oiled or greased material has been introduced by Jomac Inc., Philadelphia, Pa. Known as Oilmacs, Jomac gloves have been treated to prevent the thick loop-pile fabric from absorbing oil. They do not become heavy and cumbersome as do oil-soaked gloves. At the same time they do not become slippery from oil, hence permit a good grip on the article or material handled. The thickness and flexibility of the material cushions the hands against sharp edges, making the new Oilmac work gloves particularly useful in handling metal sheets and strip which have been oiled for fabricating as well as the parts themselves. The glove also cushions against rough surfaces and bruising blows.

THERMISTOR-TYPE TEMPERATURE INSTRUMENT

Full-scale temperature readings over a very small range, selectable anywhere in the region from —50 to +500F, are made reportedly possible by the Royco Thermi-tem temperature-measuring instrument. Depending on probe design, measurements can be made on surfaces of either conducting or insulating materials, or inside penetrable masses. Standard instruments are available with any even 50-degree or 100F scale within the overall range from —50 to +500F. Scales are linear and accuracy of the instrument is claimed to be two per cent of full-scale reading. The Thermi-tem instrument has the indicating meter in a sturdy case with the probe mounted at the end of a six-ft flexible cable, although cables of special length can be supplied. Straight, needle, or right-angle tips can be specified as required.

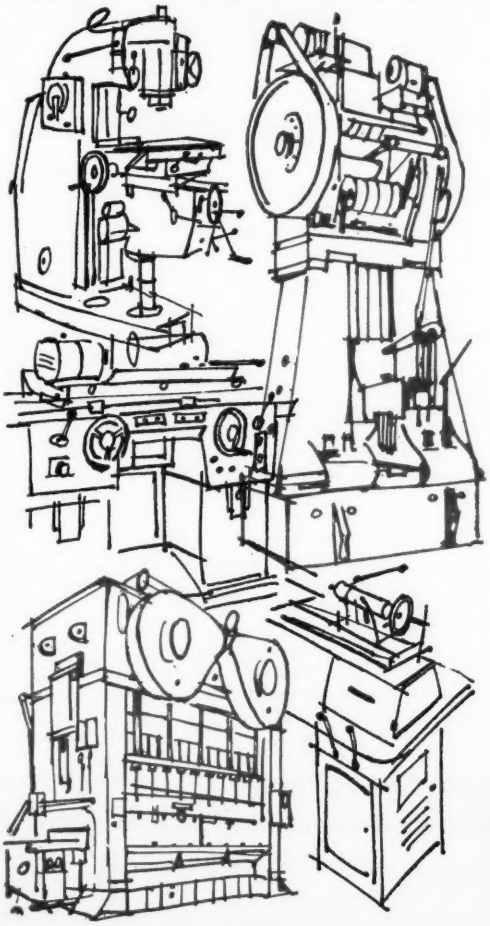
SECTION NEWS

Baltimore—"Some Problems in Steel Mill Lubrication" was the paper discussed by Hyman J. Verner, Eastern Stainless Steel Corp. at the October 22 dinner meeting . . . **Milwaukee**—Ross Robinson, Standard Oil Company spoke on metalworking and coolants at September meeting. A short film helped illustrate his talk and questions were answered . . . **New York**—At dinner meeting October 14, the New York Section held a panel meeting on plant lubrication. The panel members were S. Fuchs, Kollsman Instrument co., J. Levitan, Circle Wire and Calbe Co., H. D. Lewis, Con Edison, and J. Olsen, the Flintkote Co. with J. M. Fike, Mobil Oil Co. as moderator . . . **Pittsburgh**—Meeting on September 10 brought 33 members for dinner and 42 members for technical session. . . . **Rochester**—Joint meeting was held with **Buffalo** Section. Cort Miller, Eastman Kodak Co. discussed "Synthetic Bearings and Their Application". . . . **Toronto**—V. R. Molhall, Canadian General Electric Co. spoke on "Electrical Insulating Oils and Their Importance in Industrial Equipment" at the September 8 meeting.



ATLANTIC LUBRICANT 54

Performs on all types of grease-lubricated machinery • Cuts cost • Reduces lubricating errors



Atlantic Lubricant 54—an outstanding multi-purpose lubricant—assures:

- **Wider application**—almost universal application to grease-lubricated equipment in plants of all sizes
- **Excellent performance** at very high to extremely low operating temperatures
- **Reduced losses** from lubricating error
- **Lower costs** of warehousing and handling
- **Outstanding rust protection** for all ferrous surfaces
- **Unusual stability** against oxidation and softening—even under very rugged conditions
- **Easy, positive identification**—thanks to Atlantic Lubricant 54's distinctive purple color

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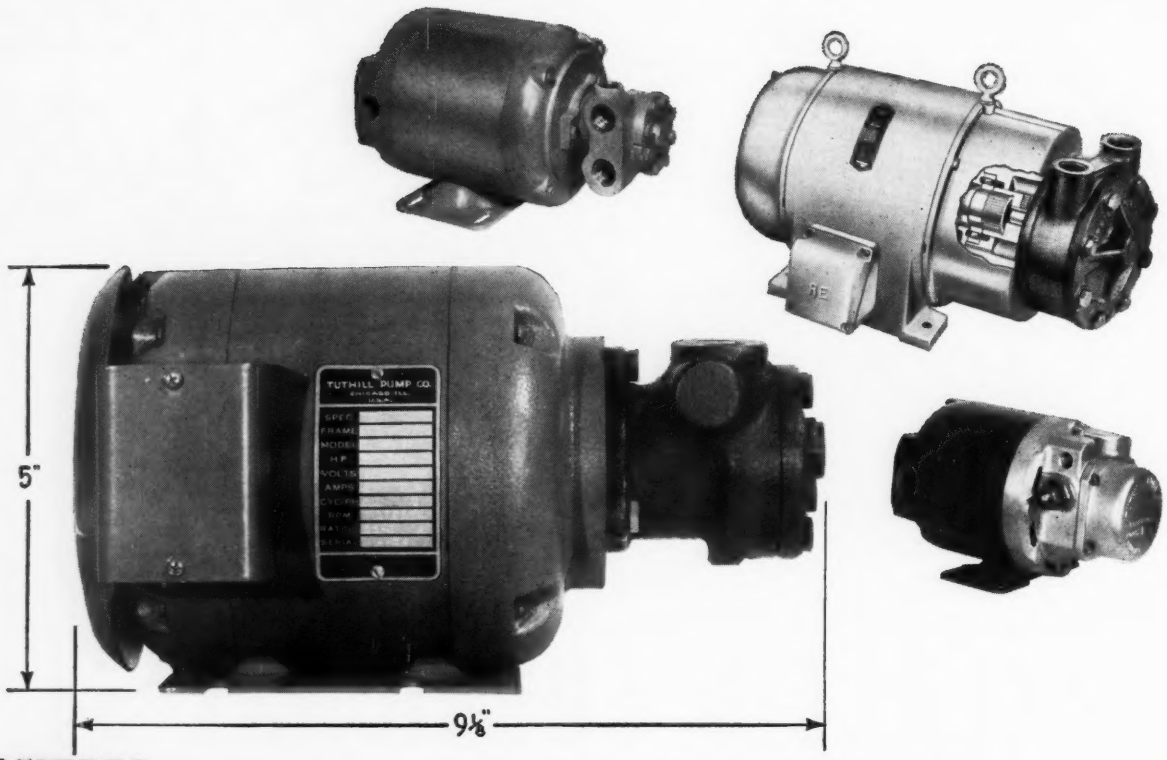
In South America
Atlantic Refining Company of Brazil, Rio de Janeiro



NEW pump & motor combination

adds to TUTHILL'S complete close-coupled line

The new Series 42 shown above further extends Tuthill's complete line of close coupled pump and motor units. These compact combinations have been especially developed to solve design problems and cut costs in hydraulic, oil burning, lubrication and a wide variety of other services.

As shown above, this compact new unit has overall measurements of only 9⅛" by 5". The totally enclosed motor is supplied with ratings of from 1/12 to 1/6 hp, while the pump units have a capacity of 1/3 to 3 gpm. The Series 42 may be supplied either with or without a built in relief valve.

Some other models in Tuthill's line of close coupled combinations are also shown above. These include a broad selection of units with capacities up to 50 gpm, for pressures to 500 psi.

Save space, weight and money

The compact design of these units solves tough design problems. The elimination of couplings, bases and adapters results in significant savings. The reduction of weight lowers shipping costs. And their compactness often simplifies assembly operations for further savings in production costs.

Available from stock

All the units shown above, plus many others are immediately available from stock. There is no minimum quantity requirement . . . so you can use these economical units in a wide variety of applications.

"POWERMITE" for OEM applications

For original equipment applications involving substantial production runs, Tuthill offers further savings in space and weight through the use of the POWERMITE. This is an exclusive Tuthill design in which pump and motor are incorporated into one unit, which takes up no more space and weighs no more than a conventional motor. For example, the Powermite shown at lower right above, measures only 8 1/6" by 4¾" . . . has a capacity of 16 gph at 350 psi.

Tuthill's engineers will be happy to develop a Powermite specifically designed for your OEM application . . . providing the greatest possible saving in space and weight.

If you are trying to incorporate a pump and a motor into a limited space Tuthill has the answer. An experienced Tuthill field engineer will be happy to give you the details. Write today.

Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 GPM; for pressures to 1500 PSI; speeds to 3600 RPM.

PUMPS FOR YOUR PURPOSE

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GRAPHITE PRODUCTS

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American Manufacturing Corp.
Industrial City, Any State

Thank you, Mr. Johnson--

for your inquiry about Dixon Colloidal Graphite.

The ultra-modern techniques used in refining and processing Dixon natural graphites result in a wide variety of products--each designed to take full advantage of graphite's amazing versatility.

For instance die-casters, forging plants, permanent mold plants, glass manufacturers--and many more--by actual production tests, have proven the superiority of Dixon natural graphites.

A wide variety of dry powder and colloidal suspensions are now available. The vehicles range from high purity oils to new synthetic, ashless fluids. These products are approved by manufacturers for use in automatic lubricating systems and spray equipment.

In connection with your own specific problem or application, may we suggest you write us, today?

Technical information, product data sheets, performance bulletins and trained technical field assistance are available ...immediately.

Sincerely yours,
THE JOSEPH DIXON CRUCIBLE COMPANY
E. M. Stum
Manager
Graphite & Lubricants Division

P.S.: Dixon graphites are currently being incorporated in the products of many grease and oil compounders and blenders.

Ed - Suggest we send for this! OK J.W.J.

PERSONALS

H. Follett Hodgkins, chairman of the board of Lipe-Rollway Corporation, and Rollway Bearing Company, of Syracuse, New York, has been named co-chairman of a special citizen's group formed to plan and help carry out major municipal redevelopment projects and governmental reorganizations in the Syracuse area. Called the Metropolitan Development Association of Syracuse and Onondaga County, the group has as its main aim to speed up modernization of the area by taking "some of the new facilities and services long proposed for this area off the planning board and putting them under construction or in use." Hodgkins will, with Dr. George L. Haller, vice president of General Electric Co., the other co-chairman, head a group made up of influential Syracuse business, industrial, financial and educational leaders.

Dr. Robert K. Gould has been named Assistant to Manager of Technical Services Division, located at the Texaco Research Center, Beacon, New York. He is a member of the American Society of Lubrication Engineers and is currently Vice Chairman of the Program Committee. Gould served as Editor of Lubrication Engineering.

R. K. Gould

Dr. Donald S. Arnold has been named manager of research at American Potash & Chemical Corporation's main plant at Trona, Calif., according to an announcement by Joseph C. Schumacher. AP&CC vice president in charge of research. Arnold previously was head of the high energy chemicals section of the AP&CC Henderson, Nev., plant research laboratory.

Appointment of Stanley R. Curtis as Project Engineer for Tranter Manufacturing, Inc., Lansing, Mich., is announced by C. C. Smith, Chief Engineer for Tranter, manufacturers of truck refrigeration systems and heat transfer units.

R. S. Edwards has been named manager of petroleum market sales at Reynolds Metals Company headquarters, Richmond, Va.

Ray R. West, who formerly headed the control devices section of Minneapolis-Honeywell Regulator Co., has been named manager of the new industrial controls division. Veteran of 35 years with Honeywell in the field of industrial instrumentation, West has been transferred from the firm's Brown Instruments Division headquarters in Philadelphia to Honeywell's home office in Minneapolis.

R. R. West

Marshall S. Lutz has been named Kobe, Inc.'s eastern sales representative according to an announcement by W. F. Slater, vice president, sales, for the West Coast firm. Lutz will headquarter in Detroit, Michigan in a new office recently established.

E. E. Smith has been appointed manager of Climax Molybdenum Company's Chemical Division. Smith previously served the company as Manager of Chemical Sales. He joined Climax in 1955 as Manager of Lubricant Development and was responsible for the introduction of Molysulfide additive to the chassis grease market as well as several new industrial fields.

E. E. Smith

Nalco Chemical Company, a major producer of industrial chemicals with headquarters in Chicago, has named Dr. David G. Braithwaite to the new post of executive vice president in charge of manufacturing, research and development.

The appointment of Dr. W. R. G. Baker as chairman of the executive committee of the board of directors of Gulton Industries, Inc., was announced recently.

The appointment of **Peter S. Vail** to the sales staff of Jefferson Chemical Company, Inc., was announced recently. Vail will be assigned to the company's Regional Sales Office in Chicago. A native of Cincinnati, Ohio, Vail is a graduate of Lehigh University, Bethlehem, Pennsylvania, with a B.S. in Chemical Engineering.

Appointments of district engineers to four sales offices are reported by The Torrington Co., manufacturer of antifriction bearings. George W. Ging has been assigned to manage the South, Seattle, Wash. office. Douglas B. MacLaren will direct the Houston, Texas office. Leonard C. Larsen has been assigned as assistant to E. G. Rowlett in the Los Angeles office. Gordon Duncan is joining the staff of the Torrington office.

The appointment of Edgar K. Lofton as manager of railway sales was an-

(Cont. on p. 468)

20-PAGE REPORT

New LABORATORY REPORT from BEMOL, Inc.

TELLS HOW
MOLY COMPARES

with Graphites, E.P., and Non-Additive Lubricants

WRITE FOR YOUR COPY

Over 50 composite charts explaining how "MOLY" compares on the Falex Machine, Timken Tester, Shell Four Ball, Kinetic Friction Apparatus, etc., in . . .

- Frictional Properties
- Load Capacity
- Temperature Reduction
- Wear Reduction
- Film Endurance

"a comprehensive report comparing moly lubricants against Graphited, E.P. and Non-Additive Lubricants

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• YOUNGSTOWN 125 W. Commerce St. Youngstown 3, Ohio

• FORT WORTH 1414 Electric Bldg. Fort Worth 2, Texas

• SPOKANE 1654 S. Maple Blvd. Spokane, Washington

Big Hit for Decca --DARINA

Decca Records, Pinckneyville, Illinois use Shell Darina Grease 2 for the entire plant's grease lubrication.

When Decca Records opened its Pinckneyville plant late in 1957, they required a high-temperature grease for their hot plasticizing mills. After testing many greases under actual plant conditions, Shell Darina Grease 2 was selected. In fact, Darina® proved so successful in its original application that Decca now uses it throughout the plant.

Darina Grease 2 is a premium-quality, multi-purpose grease with exceptional stability in extended high-temperature applications. It offers excellent resistance to corrosion and oxidation. It gives outstanding performance (compared with conventional soap-type greases) for long-time wet or dry applications at temperatures as high as 350° F.

For complete data on Darina Grease, write Shell Oil Company, 50 West 50th Street, New York 20, New York, or 100 Bush Street, San Francisco 6, California. In Canada: Shell Oil Company of Canada, Limited, 505 University Avenue, Toronto 2, Ontario.

SHELL DARINA GREASE

the multi-purpose, high-temperature grease

SHELL

HENRY CORT *made a vital and far-reaching contribution to the steel industry when he patented his rolling process in England, in 1783. Before Cort designed and built a practical rolling mill, tilting hammers had been used to produce iron bars. This laborious process produced only about one ton of bars in 12 hours. Cort first shingled his iron into half blooms at welding temperature, then reheated and passed the hot slabs through grooved rollers of his own design. In this way he was able to produce no less than 15 tons of bars in a 12 hour period.*

While not the first to attempt rolling, Henry Cort's successful process justly earned him the title "father of the rolling mill."

Great Names in Steel Making

Henry Cort's rolling mill followed a pattern as old as steel making. Whenever the need has become great enough, the right men have always developed the proper process or product to meet it.

In the modern field of industrial lubrication one thinks of such developments as the "E. P." lubricants which made today's high speed rolling mills practicable, of "Palmoshield" which freed America from dependence on imported palm oil, and of the wire drawing and cable lubricants which Ironsides engineers have originated in answer to compelling needs.

In pace with steel rolling progress for nearly 70 years, Ironsides "Gear Shield" is today synonomous with satisfactory roll neck lubrication. So much so, that others frequently refer to their lubricants as "gear shields," even though Gear Shield is the exclusive trade mark of The Ironsides Company.

That steel men recognize this contribution is evidenced by the fact that nearly every major steel producer uses "Gear Shield" lubricants.

Today's rolling mills, so far advanced beyond Henry Cort's pioneer process, demand equally high standards in lubricants. Ironsides engineers work closely with superintendents, lubrication engineers and rollers on problems of temperature, pressure, pumpability and water repellency. Ingenuity and research are put to work until a completely satisfactory answer is found. For example, Ironsides roller bearing Shield, developed to meet the need for an extreme pressure lubricant, has load-bearing capacity in excess of bearing manufacturers' standards, and carries the approval of leading bearing makers as a result.

Ironsides engineers are prepared to "custom tailor" lubricants for the specific conditions and preferences of the individual mill. We will supply these specialized lubricants in any quantity from pail to tank car.

If you have a problem, our engineers would like to help you lick it. Their experience is at your service, without obligation. Address, or phone, The Ironsides Company, Columbus 16, Ohio.

Jos. MARGULIES.

DIG INTO YOUR GREASE!

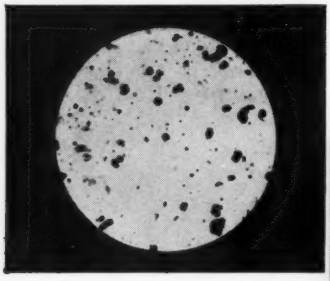
. . . you'll find you get greater MoS_2 coverage per dollar and a more uniform blend by adding Acheson dag® 208

Unless you look carefully, you may find it difficult to distinguish between greases made with different molybdenum disulfide additives. They may appear alike . . . even feel the same . . . but that's where the similarity stops. By actual photomicrographic comparison, the finer particles in 'dag' Dispersion 208 are your assurance of greater coverage . . . at no increase in solids content. Or, looking at it another way, equal coverage and greater effectiveness can be obtained at a much lower solids content, thus extending the range of application to even closer-tolerance mechanisms.

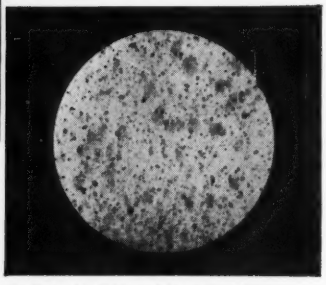
Because of the ease with which 'dag' 208 can be handled, measured and blended, there are additional savings in compounding time and labor. This stable dispersion assures the blender and the end-user of a consistently uniform grease.

If you are one of the many progressive *marketers* now considering adding a moly-fortified grease to your line, we urge you to evaluate 'dag' 208 today! If you are one of the many current *users* of moly-fortified lubricants, be sure to specify that the ones you purchase are formulated with Acheson's moly dispersions. Send in the coupon for a complimentary sample.

The same advantages of molybdenum disulfide can be incorporated in petroleum oils and polyalkylene glycol fluids. 'dag' Dispersions 200 and 207 are the finest colloidal concentrates available for these applications. Experimental samples may be obtained upon request.



Shown here is a dramatic comparison of particle sizes. Both Acheson's new dispersion, 'dag' 208, (below) and the finest commercially available molybdenum disulfide powder (at left), have been magnified 300 times.



Tests prove that the predominantly finer particles in 'dag' 208 (at right) provide 80% greater hiding power . . . more coverage per dollar.

Acheson Colloids Company

Dept. LE-119, Port Huron, Michigan

Please send me free of charge your trial sample of

'dag' 208 ☐ *'dag' 200* ☐

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Lube Lines

by A. F. Brewer*

THE VALUE OF PLANNING

For lubrication to be effective it must be planned. This means that the prospective operating conditions must be considered when the machine is being designed. The extent to which lubrication ultimately can be maintained will depend on how thoroughly the designing engineer considers these prospective operating conditions and the means available for lubrication. It is advisable to always consider the ultimate location of the machine and to what extent the moving contact parts may be exposed to abrasive foreign matter. Where it is possible to plan the design to include proper seals and automatic lubrication, the increased cost often will be justified by the possibility of using more suitable lubricants in service. The same holds true for temperature control.

Machinery usually must run under varying operation conditions unless very high precision work is being produced, or sensitive products are to be handled. Under such conditions humidity, temperature and speed control are practicable. Normally, however, industrial or power plant machinery is operated at temperatures which will vary with room temperatures, and at speeds commensurate with the loads.

Wide temperature fluctuation can have a pronounced affect upon the fluidity or consistency of the lubricant. Under lower than the normal temperatures for which the lubricant may have been selected it will tend to become sluggish. In a ring oiled electric motor bearing this might result in starved lubrication through insufficient oil being carried over by the ring. In a pressure grease lubrication system where long lengths of pipe may be exposed to sudden reductions in temperature the pumping units might be incapable of handling some types of grease which may become chilled to solidity. Here again the result could be starved lubrication.

Usually it is impracticable to do anything about temperature drop due to weather conditions, but it is practicable to use a lubricant which will be least affected. Petroleum oils go through a natural change in viscosity with change in temperature. The viscosity-temperature chart (ASTM) is of value in predicting how serious this change in viscosity can become under the probable temperature drop. One can judge the relative fluidity of the oil as indicated by the chart, in comparison with a known product, for example a steam cylinder oil or a SAE 140 gear oil. Service control is practicable by planning for a water circulating system as an adjunct to the lubricating system, to enable cooling in warm weather and pre-heating for cold starting, as required on machinery such as gyratory crushers which are subjected to wide ranges of operating temperatures.

Speed and load must also be considered when planning lubrication for any mechanism. Varying the viscosity inversely with the speed is axiomatic when dealing with oil lubrication. To some extent this rule also can be applied to grease although it is not quite as easy to completely flush a bearing of an NLGI No. 2 or No. 3 grease preparatory to using a No. 1 grade if plant conditions call for speed-up. The more usual way of regarding this axiom, therefore, is to apply it when selecting the original lubricant vicosity or consistency according to the design of the lubricating system.

The function of the machine obviously is a factor. A reciprocating boiler feed pump, for example, would not warrant as careful consideration of its lubrication as the bearings of a steam turbine. There is, however, a definite trend towards better housing of machine parts, which of itself contributes to better protection of lubricants against contamination. This applies particularly to reduction gear sets and chain drives. This trend towards better housing or enclosure of working parts lends more justification for the recommendation of lubricants of higher quality. Loss through drip or throw-off will be reduced. There will be less chance for contamination. The life of a charge of lubricant will be extended and fire hazard will be reduced.

The ideal is not always attainable, however; it may be impossible to correct conditions which would promote waste or contamination. Then the designing engineer would be justified in planning for means of once-through lubrication such as oil cups or compression grease cups, with the idea that more frequent lubrication would prevent abrasive foreign matter from working into bearing clearances.

The lubrication engineer fits into this picture in service as it is his responsibility to recommend the most suitable grade of oil or grease in accordance with the design, the means for application, the chance for contamination and the speed, load and temperature. Naturally the age of the machine must be considered. Whereas a modern type of design might justify the use of an oxidation inhibited grease or a detergent type oil, an older machine could be equally as well protected by a cup grease or straight mineral oil, with the expectation that more frequent application would be necessary. These would be matters for the lubrication engineer to work out with the operating people. It can be seen, therefore, that a working lubrication recommendation might include two or more oils of the same viscosity range, or greases within the same NLGI range of penetration. Practical economics may often require that a secondary recommendation be available if price becomes a factor.

* Consultant and author "Basic Lubrication Practice."

"Since Cities Service Pacemaker 300 T-Injection molders operating perfectly."

Daniel A. Goetz, President and Charles R. Goetz, Dan's twin brother and Vice President of Stylette Plastics, agree on the value of a superior hydraulic oil. As Dan Goetz says, "we produce millions of 'giveaway' items every year. These items must be inexpensive . . . and to obtain the lowest cost possible we must produce in quantity and without expensive down-time on our injection molding machines. We had previously had trouble with our hydraulic oil and I think it was primarily due to the heat involved. We called in the Cities Service Lubrication Engineer and he switched us to Pacemaker 300 T. **Since using Pacemaker 300 T, our six injection molders have been operating perfectly."**

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The Goetz Twins, owners of Stylette Plastics went into the plastics business in Pittsburgh in 1952 on the recommendation of their professor at Duquesne University. They started with $1,500 and bought a nine ounce injection molding machine to make plastic tile.

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Vol. 15, No. 11

Lubrication Engineering

"In the laboratories, lubrication engineers seek answers to higher speeds, higher temperatures, more corrosive environments."

still on top

Again we would like to refer you to "A Digest of 1958 Literature—Bearings, Lubricants and Lubrication," MECHANICAL ENGINEERING, October 1959, which brings ASLE to the fore as the primary publisher of scientific literature in this field. On the over-all subject, ASLE put into the archives 30.7 per cent of the permanent United States literature. Two hundred and seventy-seven references were listed in the Digest. Eliminating foreign journals, government technical reports and preprints of papers, a total of 153 remains. Out of the 153, ASLE was responsible for 47 or a percentage of 30.7! This constitutes the greatest number of references to any one group and is greater than the next top three groups combined.

While this percentage is lower than in 1957 (36.6%), it does not mean that the Society is not publishing as many papers in this field. On the contrary, ASLE published more articles in 1958 than ever before. It is due to greater publishing effort in this field by many other publications. As a matter of fact, more than 35 individual publications were included in the digest of references.

It is interesting to note the distribution of reference according to specific areas: Fluid Film Bearings, 53; Ball and Roller Bearing, 42; Friction and Wear, 44; Automotive Lubricants, 54; Metalworking Lubrication, 26; Lubricant Properties, 58. In certain specific areas such as Metalworking Lubrication and Lubricant Properties ASLE really showed its colors by contributing 37 per cent and 44 per cent respectively of the literature.

Our thanks to the research scientists, authors, program committees and others who solicit articles and papers. We'll continue to be out in front—with their help.

Calvert L. Willey
Executive Secretary

LUBRICATION OF Air Cooled and Water Cooled TWO-STROKE CYCLE ENGINES

This paper presents a discussion of the theory of lubrication of two-stroke cycle engines and the various requirements of a lubricant for these engines. It is also a report of tests to find a single lubricant suitable for both air cooled and water cooled engines. Outboard motors and chain saw engines were used. Results of the test work done to date are given and a preliminary specification of such a lubricant is presented. The need for much more research by lubrication engineers and the petroleum industry to find the exact specification for a satisfactory lubricant for all two-stroke gasoline engines is emphasized.

by Lowell E. Haas
McCulloch Corporation, Minneapolis, Minnesota

Several American corporations manufacture both air cooled and water cooled two-stroke cycle engines. For these it would be an advantage to be able to specify one lubricant which would lubricate both satisfactorily.

The American home owners are buying two-stroke cycle engines in chain saws, power lawn mowers, motor scooters, and other products at the rate of more than a million units per year. They are also buying two-stroke cycle engines in outboard motors at the rate of 600,000 units per year. In most cases, the chain saws, lawn mowers, motor scooters, and associated engines are air cooled, while the outboard motors are water cooled. Because of this homeowner use, the mechanics of lubrication of these engines and the specifications for choosing a lubricant from the many available have become of universal interest.

For these two reasons, a project was begun with outboard motors and chain saw engines to develop a dual purpose lubricant.

TWO-STROKE CYCLE ENGINES

The two-stroke cycle engine is becoming very familiar and its principles of operation are well known. However, in order to emphasize the path that the lubricant takes in passing through the two-stroke cycle engine, the basic strokes and events happening in the two-stroke cycle, spark ignition engine will be reviewed. In the two-stroke cycle engine, every downward stroke of the piston is a power stroke. Therefore, every upward stroke must be a compression stroke, and the only point in the cycle for intake and exhaust functions is near bottom dead center. Fig. 1(a) shows schematically a two-stroke cycle engine at the beginning of compression of the charge in the combustion chamber. It also shows that the fresh fuel-air mixture for the next cycle is being drawn into the crankcase through one-way reed valves. Fig. 1(b) shows the piston at top dead center following the compression stroke and ignition of the charge. Fig. 1(c) shows the piston being pushed downward on its power stroke from the combustion of the charge in the chamber, and, also, the compression of the fuel-air mixture for the next charge in the crankcase beneath the piston. Fig. 1(d) shows the exhaust of the burned charge from the power cycle and, also, the re-charging of the cylinder with the fresh fuel-air mix which was compressed in the crankcase during the power stroke. Since the piston and the sealed crankcase comprise a pump for charging the cylinder, advantage is taken of this to make the engine simple by utilizing the incoming mixture as a carrier for the lubricant of the engine. Lubricant can be mixed with the fuel in a wide range of proportions by volume. However, the usual proportion of lubricant to fuel is 16 parts of fuel to one part of lubricant, or a half pint of oil per gallon of gasoline. The point to be emphasized is that the lubricant for the engine is homogeneously mixed with the gasoline and is carried into the crankcase of the engine by entrainment in the air. The mixture is held for a few thousandths of a second in the crankcase in contact with the moving parts in the crankcase and with the underside of the piston, and then transferred

Presented before the 14th ASLE Annual Meeting, April, 1959.

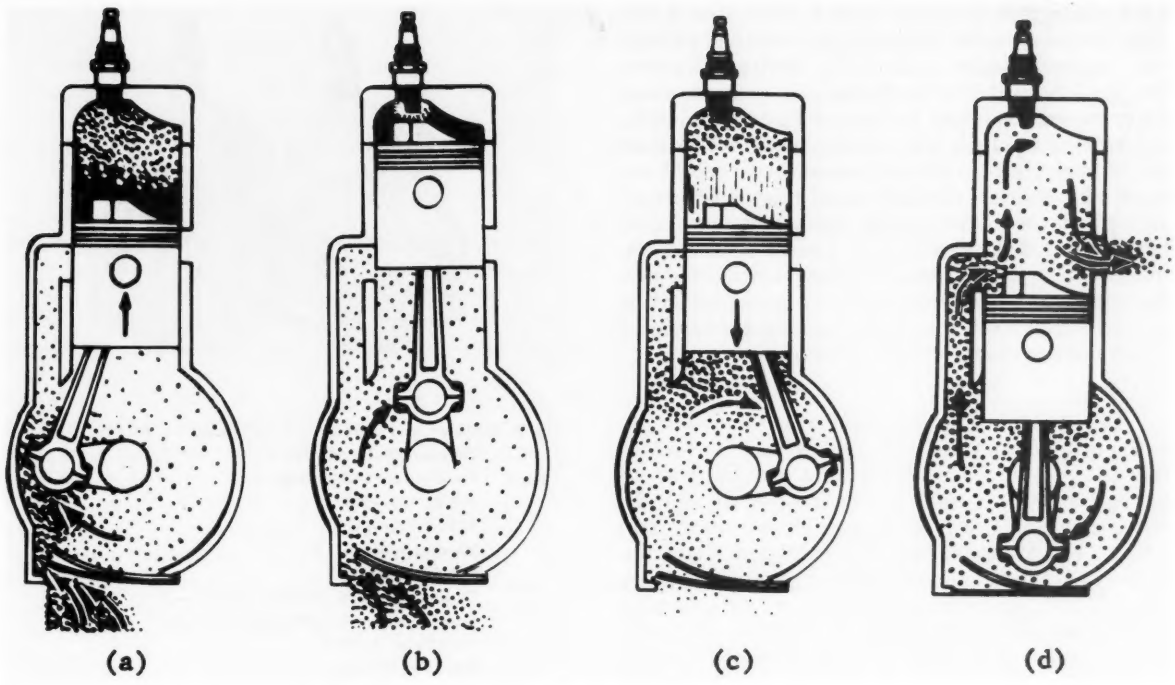

Fig. 1. Schematic drawings of two-stroke cycle process.

into the combustion chamber through the transfer passage and the intake ports while the piston is at bottom dead center. Lubricant is carried through the engine in a steady stream and performs its function in a single pass through the engine. A state of equilibrium exists with as much oil leaving the engine as enters each cycle; however, the path of exit changes with different speed and load conditions. At part throttle some lubricant drops out of the moving air and is removed from the crankcase by drain passages. At full throttle most of the lubricant remains entrained and reaches the combustion chamber.

Oil consumption of the two-stroke cycle engine is roughly 250 times that of a comparable four-stroke cycle engine and is one of the fruitful areas of work to reduce the cost of operation of these engines.

Air entrained lubrication has the disadvantage of supplying too much lubrication at low load conditions and barely adequate amounts at high load conditions. This is because velocities of the air entrained fuel-oil mix are low at part throttle conditions, allowing more of the liquid to fall out of the air into the crankcase; while, at full throttle conditions, velocities are high and the lubricant remains entrained in the air. The exact reverse situation is the desirable one for economical use of lubricant.

It is obvious that the requirements for the oil in the two-cycle engine are different from those in a four-stroke cycle engine and will be examined in detail below.

REQUIREMENTS FOR A TWO-CYCLE ENGINE LUBRICANT

Film Strength—The lubricating oil which impinges on the cylinder walls swept by the piston must retain its film strength sufficiently to lubricate satisfactorily the piston skirt proper and, also, to lubricate the piston rings in their face contact with the cylinder wall and the face contact with the piston ring groove. That portion of the lubricant which adheres to the cylinder walls must resist burning sufficiently to prevent metal to metal contact of the piston with the cylinder walls or seizure of the piston will result. Fig.

Fig. 2. Scored piston—oil endurance run #2.
Outboard Motor Oil "E"
Naphthenic Base SAE 30
SUS @ 100—783
SUS @ 210—58.2
Viscosity Index—0
Carbon Residue %—.06
Flash Point °F—395
Fire Point °F—445
Gravity °API—19.3
Pour point °F— —5
Test run on new 7½ HP outboard motor, continuous @ 5000 rpm max. torque for five hours. Automotive regular fuel. Fuel-oil ratio 16/1.

2 is a photograph of pistons from a water cooled outboard motor operated with a naphthenic base oil having a viscosity index of zero. The photograph shows that the lubricant had insufficient film strength under the operating conditions to resist seizure of the piston, and scoring resulted. The scoring is on the exhaust side of the cylinder wall and was initiated at the exhaust ports which is the hottest and most difficult area to lubricate in the two-stroke cycle engine cylinder. Port bridges deflect, rings are exposed to hot gases, and metal to metal contact occurs. It will be shown that the mechanism by which the main and connecting rod bearings are lubricated also requires the lubricant to have film strength at high temperatures.

Low Residue—The lubricant which finds its way to the piston crown and the cylinder head surfaces is expected to burn completely and cleanly without leaving deposits to coat the cylinder head and the piston crown. Fig. 3 is a photograph of pistons from a water cooled two-stroke cycle outboard motor operated with a paraffin base lubricant having a viscosity index of 115. This particular lubricant had a metallic additive and shows the result of operating an engine with a lubricant in which the lubricating oil which contacts the piston crown does not burn cleanly and satisfactorily. Fig. 4 is the cylinder block from the same engine operated on the same lubricant and shows

Fig. 3. Extremely bad deposits—oil endurance run #3.
Outboard Motor Oil "G"
Paraffin Base SAE 20W-40
SUS @ 100—525
SUS @ 210—71
Viscosity Index—115
Gravity °API—28.5
Carbon Residue % (without additive)—.3
Carbon Residue % (with additive)—1.35
Flash Point °F—445
Fire Point °F—500
Test run on new 7½ HP outboard motor, continuous @ 5000 rpm max. torque for 100 hours. Automotive regular fuel. Fuel-oil ratio 16/1.

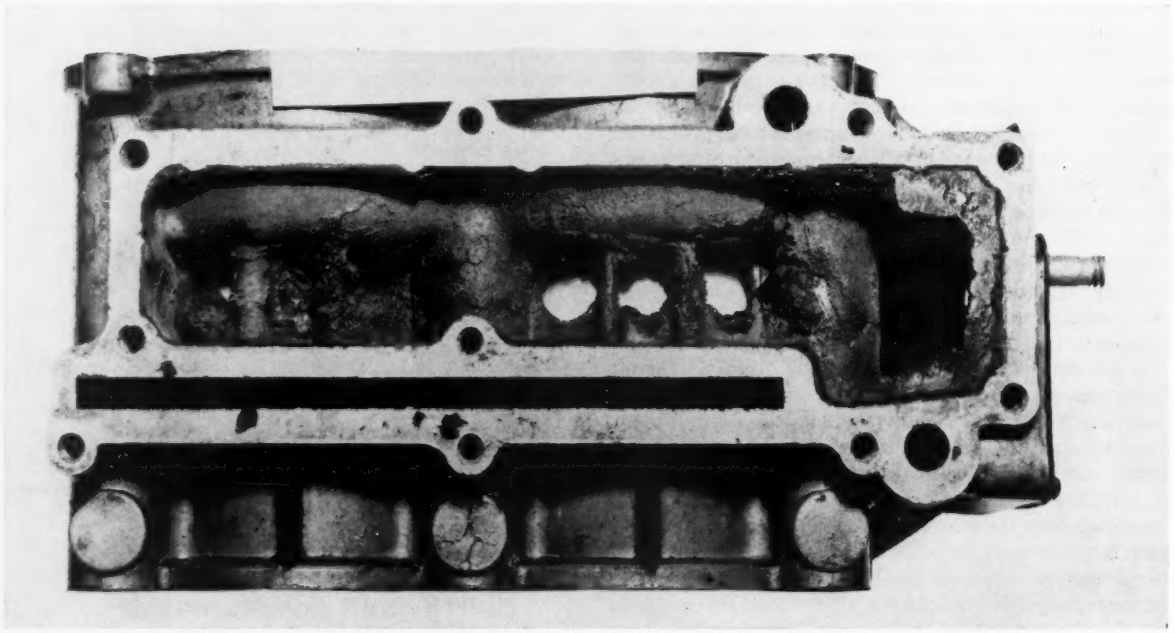

Fig. 4. Extremely bad deposits—oil endurance run #3.
Outboard Motor Oil "G"
Paraffin Base SAE 20W-40
SUS @ 100—525
SUS @ 210—71
Viscosity Index—115
Gravity °API—28.5
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Carbon Residue % (with additive)—1.35
Flash Point °F—445
Fire Point °F—500
Test run on new 7½ HP outboard motor, continuous @ 5000 rpm max. torque for 100 hours. Automotive regular fuel. Fuel-oil ratio 16/1.

that the exhaust port area was badly fouled from the lubricant which did not burn cleanly. The oil used in the tests which resulted in the condition shown in Fig. 3 and 4 is at the opposite end of the specification spectrum from the oil which was used in the tests shown in Fig. 2.

Detergency—It has been shown that the lubricant passes through the crankcase and combustion chamber of the two-stroke cycle engine in a steady flow with the fuel-air mix. It is in the engine less than ten-thousandths of a second at operating speeds. Even though there is plenty of oxygen present, excellent agitation of the oil and air mixture in the crankcase, and an elevated temperature sufficient to promote oxidation of the oil during its passage through the engine, there is insufficient time to have any oil oxidation which will cause deposits to form on the crankcase interior walls. Anti-oxidants have proved to be of little benefit. However, any blow-by of gases past the piston rings must come into the crankcase, and these do contribute to dirty engine interiors. A requirement of the lubricating oil is to cleanse the crankcase walls of this contamination by the blow-by gases. The piston crown, operating at an elevated temperature by reason of the heat load resulting from a power stroke every downward stroke of the piston, tends to thermally crack the oil coming into contact with it and can become very heavily coated with tars or hard resins. The lubricant thus has a requirement of helping to cleanse the crankcase side of the piston in the crown area.

Anti-Corrosiveness—The water cooled outboard motor operates in salt water as well as in fresh water. Of definite value are anti-corrosive additives which will prevent rusting of cylinder walls and piston rings which often are exposed to salt laden vapor. They also protect bearing surfaces when the outboard is accidentally submerged in salt waters.

Miscibility with Gasoline—The average operator refills his fuel tank by pouring in first a quantity of oil thought to be the required amount and then pouring in the gasoline. He may take the trouble to shake the container a few times, but more probably he will depend on the incoming gasoline and the subsequent motion of transportation to mix fuel and oil. For this reason, lubricating oils for present two-stroke cycle engines should mix easily with gasoline.

The requirements of the two-stroke cycle lubricant may be summarized as follows:

1. Must have adequate film strength above 300 F.
2. Must burn cleanly without residue.
3. Must have detergent and anti-corrosive characteristics.
4. Must mix easily with the fuel.

MECHANISM OF LUBRICATION FOR MAIN AND CONNECTING ROD BEARINGS

Since it is necessary that a satisfactory lubricant for two-stroke cycle engines have high film strength above 300 F, the lubricant requirements for the caged, roller, main, connecting rod, and crank pin bearings deserve further detailed study. The fuel-oil-air mixture which enters the crankcase through the one-way reed valves is directed so that it impinges on the moving parts. The need for impinging the incoming mixture directly on the moving parts, particularly the connecting rod bearings, was determined experimentally during engine development work in which failures of the rod bearings resulted when the fuel-oil-air mixture was allowed to enter without direction. Fig. 5 shows a typical failure of the crank pin end of a connecting rod in which heat was generated to the point of softening the rollers and various surfaces on the connecting rod itself. Even though the connecting

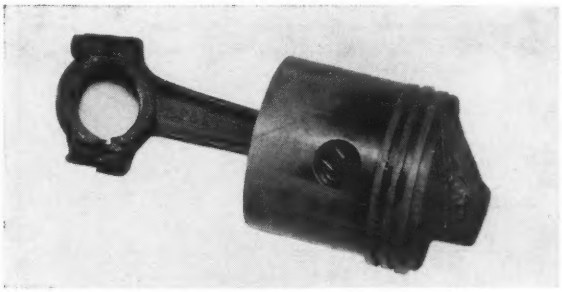

Fig. 5. Failure of connecting rod crankpin bearing.

rod bearings used were so-called anti-friction bearings, the friction of roller upon guide bars in the cages, of the caged surfaces upon the connecting rod and the crank pin, and of the cage flange on the connecting rod and the crank pin cheek generated heat to the extent that failure resulted from plastic deformation of the parts. It was found, by directing the fresh charge on to the rotating parts, that heat could be removed from these parts, largely by distillation of the fuel in the mixture to such an extent that the residual oil remaining on the moving parts was sufficient to eliminate metal to metal contact and to eliminate the failure. This distillation of the fuel from the incoming fuel-oil-air mixture, leaving residual oil on the bearing surfaces, has been outlined by Conover (1). Tests have shown that, at idle conditions in two-stroke cycle engines, the film strength of pure gasoline is sufficient in itself to perform every cooling and lubricating job in the engine. However, as soon as engine speed or load increases even slightly, the lubrication job immediately becomes more demanding, resulting in the necessity of a true lubricant being left on the bearing surfaces to prevent seizure and failure.

While it is not possible to extract samples from the rotating bearing surfaces themselves of the residual mixture remaining on the surfaces, it is possible to extract samples from various places in the crankcase and to get some idea of what is happening to the fuel-oil mixture. Fig. 6 shows distillation curves of fuel pumped from the interior of the two-stroke cycle outboard motor immediately after the carburetor and in the intake manifold. On this same sheet is plotted typical distillation curves for summer and winter

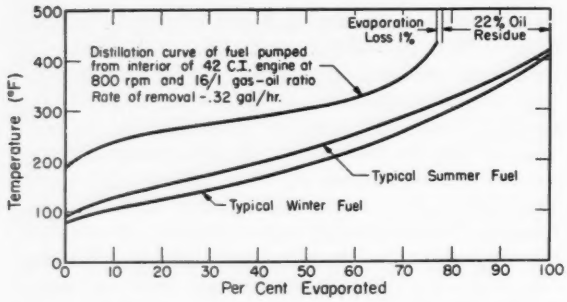
Evaporation Loss 1%
22% Oil Residue
Distillation curve of fuel pumped from interior of 42 C.I. engine at 800 rpm and 16/1 gas-oil ratio
Rate of removal - .32 gal/hr.
Typical Summer Fuel
Typical Winter Fuel
Temperature (°F)
Per Cent Evaporated

Fig. 6. Distillation curve of fuel-oil mixture sample taken from intake manifold.

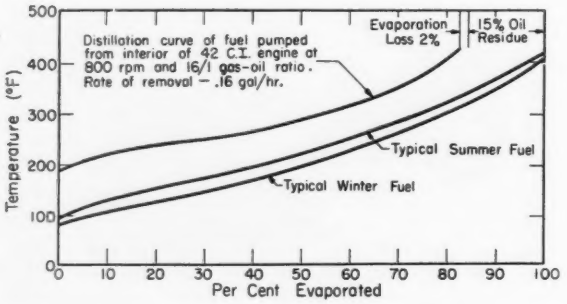
Evaporation Loss 2%
15% Oil Residue
Distillation curve of fuel pumped from interior of 42 C.I. engine at 800 rpm and 16/1 gas-oil ratio.
Rate of removal — .16 gal/hr.
Typical Summer Fuel
Typical Winter Fuel
Temperature (°F)
Per Cent Evaporated

Fig. 7. Distillation curve of fuel-oil mixture sample taken from engine crankcase.

gasolines. It can be seen that approximately 40 per cent of the light ends of the fuel have already evaporated, since the initial point of the sample taken has a distillation temperature of 183 F instead of 90 F for the summer fuel. It also shows that there was an oil residue in the sample of 15½ per cent instead of 6¼ per cent as mixed. Fig. 7 shows a similar distillation curve for a sample pumped from the interior of the crankcase of this same engine at such a point that the fuel-oil mixture had impinged on hot surfaces and collected in the crankcase after having been in contact with crankcase surfaces. It can be seen that this sample was rich in oil, having 22 per cent residue instead of 15½ per cent as it had entered the crankcase from the manifold. Both of these distillation curves were taken at relatively low engine speeds and loads. It is certain that, at the high specific output and high rotating speeds at which the engine operates under normal conditions, the evaporation of the fuel progresses to the point where there is a high concentration of lubricant left on the operating surfaces. This means that temperatures of approximately 300 degrees or more are in existence on the bearing surfaces. It is necessary that the lubricant which will satisfactorily lubricate the bearing parts of a two-stroke cycle engine have sufficient film strength at these temperatures to prevent galling.

HISTORY OF PRESENT LUBRICANTS

The manufacturers of two-cycle engines have traditionally recommended a mineral oil without any additives. This has resulted from the fact that early two-stroke cycle outboard motors and other engines were lubricated with automotive lubricants. As the requirements on the automotive lubricant became more severe, additives were added to them to improve their performance in four-stroke cycle automobile engines. However, the additives which were blended with the oils resulted in heavy deposits in two-stroke cycle engines, which fouled ports and plugs and caused great loss of power. The manufacturers of two-stroke cycle engines took the quick way out and recommended the use of straight run oils. Fig. 8 shows the type of piston crown deposits encountered with a barium additive oil. The piston skirt has been kept quite clean by the use of this lubricant and the rings are free. However, the deposits remaining on the piston crown are of the type that, in high output two-cycle engines, tend to produce destructive preignition. Barium and calcium salts in the additive can combine with the tetraethyl lead, carbon, and oxygen in the fuel to form products which will promote preignition and which will result in a rapid rate of temperature rise, causing erosion of the piston crown. Just as detonation is a limiting factor in the design of four-stroke cycle automotive engines, runaway preignition is a limiting factor in the design of high output, two-stroke cycle engines.

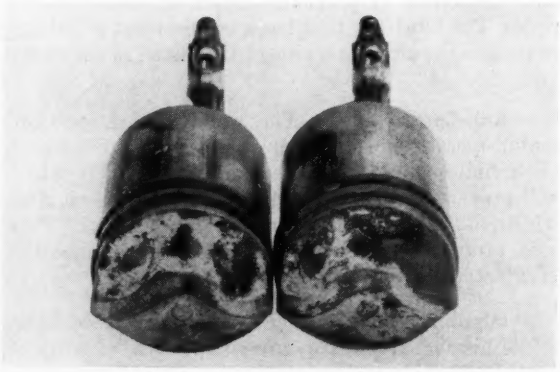

Fig. 8. Barium additive detergent-dispersant—oil endurance run #6.
Outboard Motor Oil "F"
Paraffin Base SAE 30
SUS @ 100—475
SUS @ 210—62
Viscosity Index—96
Carbon Residue %—.32
Gravity °API—28
Flash Point °F—440
Fire Point °F—495
Test run in new 7½ HP outboard motor, continuous @ 5000 rpm max. torque for 100 hours. Automotive regular fuel. Fuel-oil ratio 16/1.

Fortunately for those who are engaged in the manufacture of two-stroke cycle engines, recent developments of products called "ashless detergents" have offered a means of securing the advantages of the detergent-dispersant additives without the necessity of having to contend with the piston crown de-

posits which resulted in runaway preignition and which fouled plugs and ports. It was thus determined in the early stages of the project to secure the advantages of the ashless detergents in the final oil which was to be chosen as a dual engine lubricant.

RESULTS OF SCREENING TESTS

In the early tests carried out to determine whether the chain saw oil would work in the outboard, and vice versa, it was found that the chain saw engines offered a faster method of evaluating oils than did the outboards. Therefore, a screening test and procedure was set up using a chain saw engine, operating it on a schedule of five minutes at 5000 rpm and max. load followed by 15 minutes at 2200 rpm and no load. It was found that 25 hours of this test cycle was sufficient to accurately evaluate the results obtainable with each sample oil. The water cooled outboard motor required about 100 hours to satisfactorily evaluate oils; therefore, it was only run on those samples accepted by the chain saw screening tests. Fig. 9-14 show photographs of the results obtained in the chain saw screening test with some of the sample oils submitted by vendors for test. While it is not possible in this paper to show all the results, the most significant things in this search

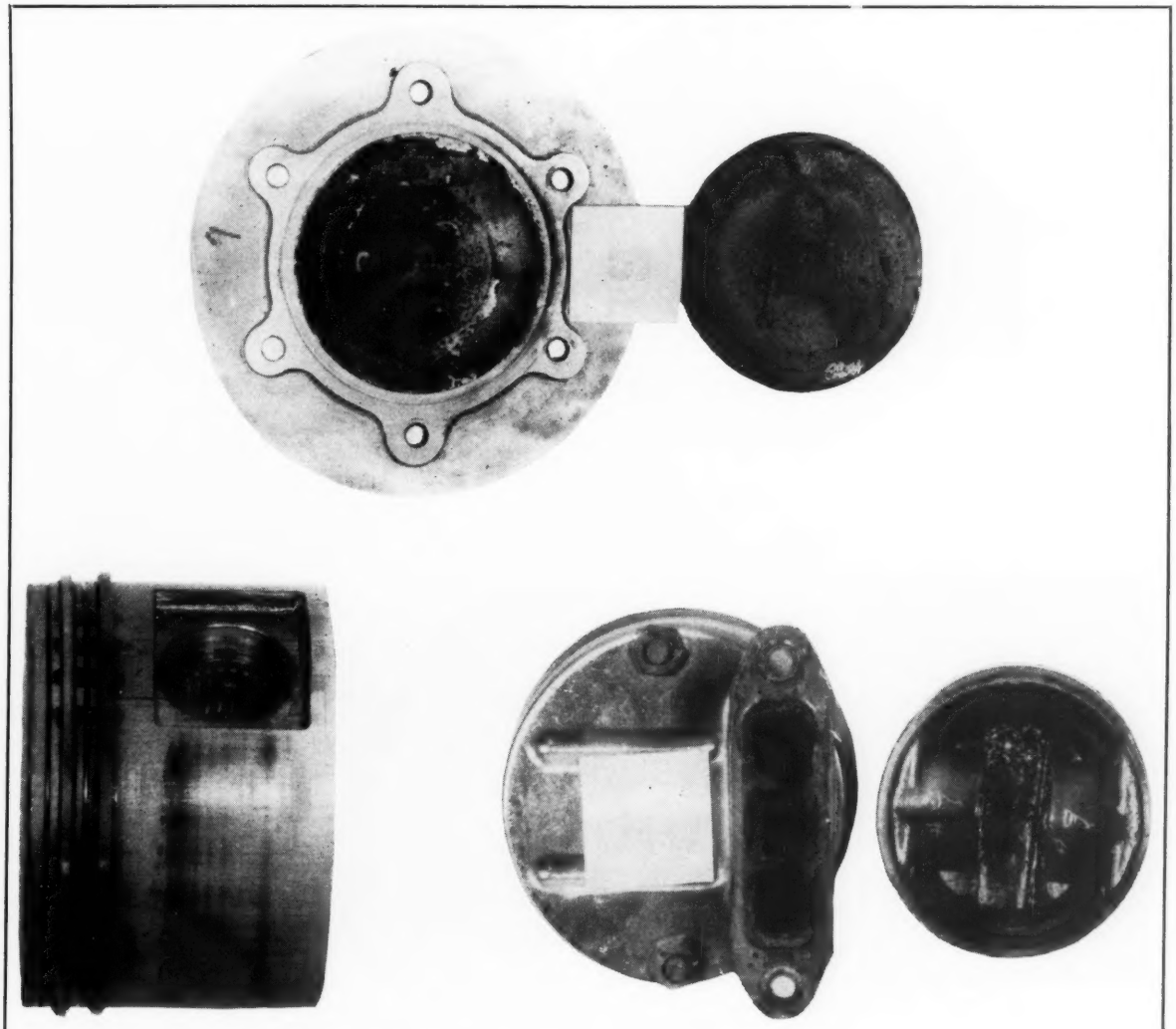

Fig. 9. Chain saw engine parts with former chain saw oil—oil screening run #9.

Chain Saw Oil
Midcontinent Paraffin Base SAE 50
SUS @ 100—1254
SUS @ 210—98
Viscosity Index—92
Carbon Residue %—.30
Gravity °API—27.2
Flash Point °F—495
Pour Point °F—10
Test run in clean chain saw engine, five min. @ 5000 rpm W.O.T. (max. torque), 15 min. @ 2200 rpm idle, 25 hr. total time. Automotive regular fuel. Fuel-oil ratio 20/1 (wt). (NOTE: Partial ring sticking.)

for a dual engine lubricant will be considered. Fig. 9 shows typical deposits when run with the oil now specified for the air cooled chain saw. This oil has given complete customer satisfaction since its choice some years ago. It is a solvent refined, mid-continent, paraffinic base oil containing no additives of any kind. Examination of Fig. 9 shows that one piston ring is partially stuck, the piston interior is well coated with varnish and heavy deposits of resin, and that the cylinder head and combustion chamber are thinly covered with deposit. The piston skirt shows evidence of gum formation and the muffler shows some clogging of the inlet passage. Fig. 10 shows the effects of one of the ashless detergents now available. It can be seen, in comparison with Fig. 9, that the interior of the piston is very clean, that the piston skirt is exceptionally clean, all rings are free, and that the combustion chamber deposit has been reduced in volume. The inlet passage to the muffler shows somewhat more plugging than in the previous figure, evidence of the deposits being taken from the interior of the engine and being removed to a part outside the combustion

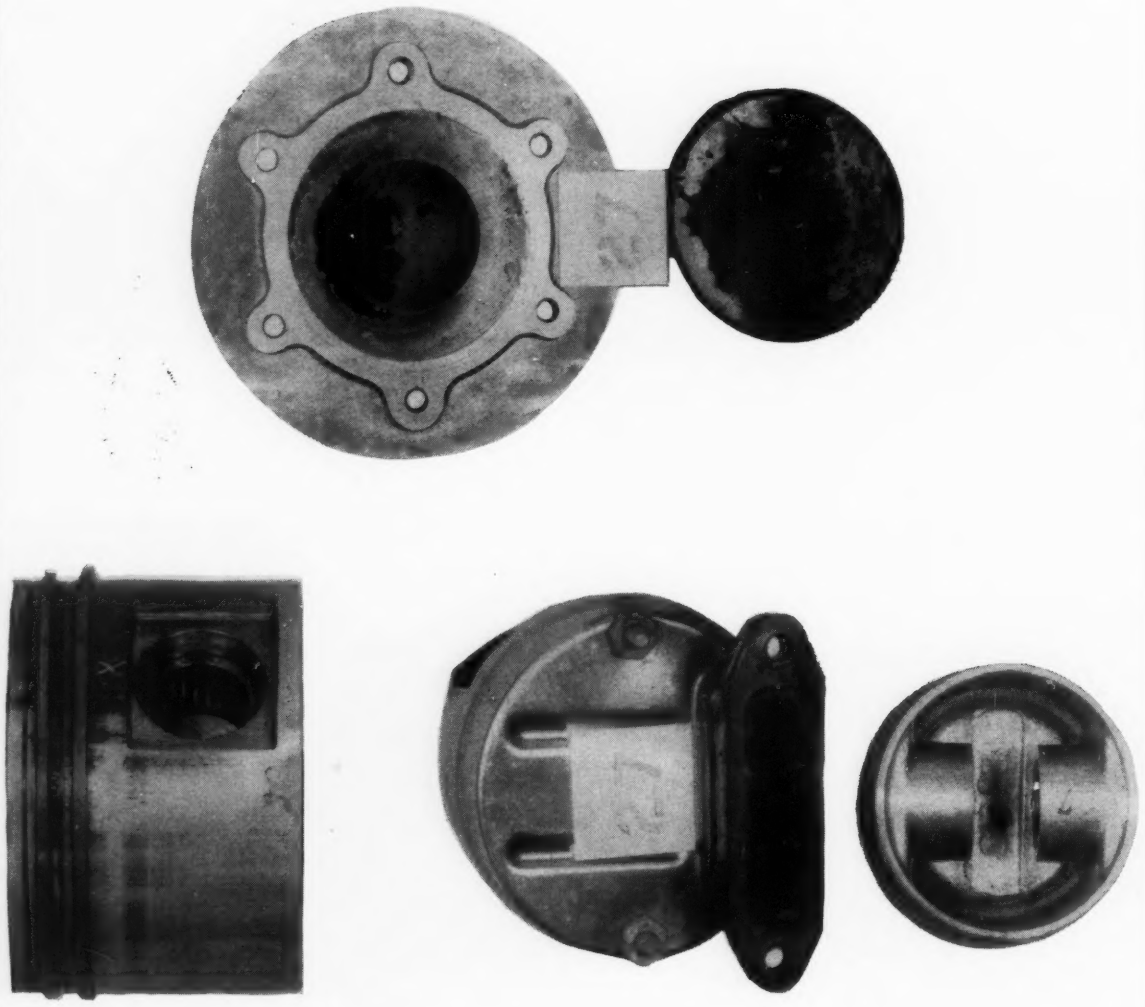

Fig. 10. Chain saw engine parts with sample chain saw oil "D"—oil screening run #27.

Chain Saw Oil "D"
Paraffin Base SAE 50
SUS @ 100—1218
SUS @ 210—99
Viscosity Index %—95
Carbon Residue %—.22
Gravity °API—27.8
Flash Point °F—505
Fire Point °F—570
Test run in clean chain saw engine, five min. @ 5000 rpm W.O.T. (max. torque), 15 min. @ 2200 rpm idle, 25 hr. total time. Automotive regular fuel. Fuel-oil ratio 20/1 (wt).

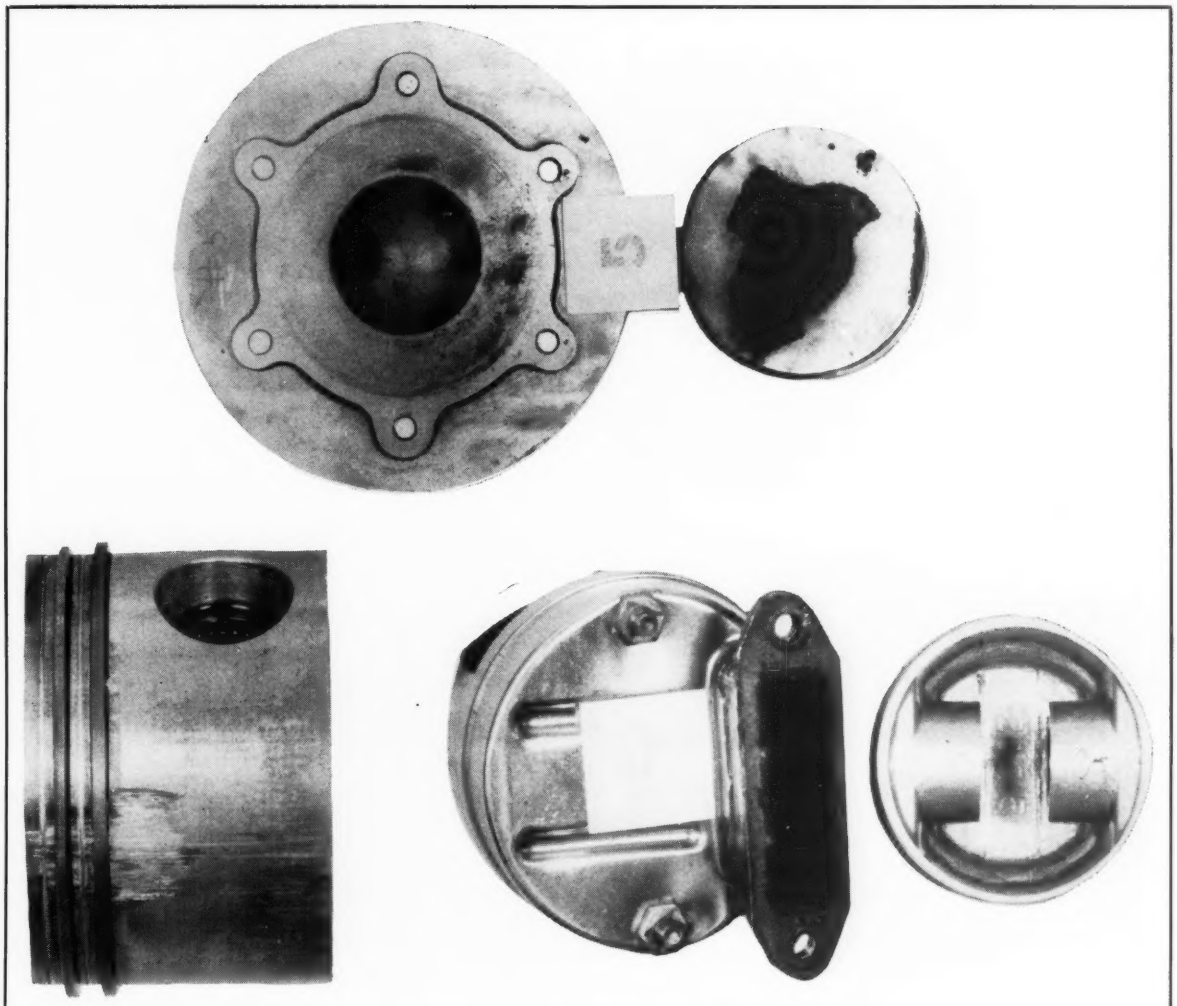

Fig. 11. Chain saw engine parts with sample outboard oil "A"—oil screening run #5.

Outboard Motor Oil "A"
Plus 5% Ashless Detergent
100% Paraffin Base SAE 30
SUS @ 100—565
SUS @ 210—64.1
Viscosity Index—85
Carbon Residue %—.10
Gravity °API—27.6
Flash Point °F—455
Pour Point °F—0
Test run in clean chain saw engine, five min. @ 5000 rpm W.O.T. (max. torque), 15 min. @ 2200 rpm idle, 25 hr. total time. Automotive regular fuel. Fuel-oil ratio 20/1 (wt). (NOTE: Slight piston scuffing.)

chamber. This is more easily cleaned and deposits are not as troublesome as in other locations. Pursuing the original goal of obtaining a single lubricant which would serve the dual purpose of lubricating the water cooled outboard motor and the air cooled chain saw engine, and since it had early been determined that the water cooled outboard engine would not accept SAE 50 viscosity oils, a series of tests was run to determine the effects on the chain saw of variation in viscosity with the most satisfactory base stock blended with five per cent of an ashless detergent. Fig. 11, 12, and 13 illustrate the engine parts with SAE 30, SAE 40, and SAE 50 weight oil respectively. It can be seen that all three illustrations show satisfactory level of internal cleanliness; however, the chain saw engine operating on the SAE 30 oil consistently exhibited the piston scuffing characteristics. This scuffing tendency with the SAE 30 oil is due to the higher cylinder wall temperature resulting from the air cooled engine operation. Subsequent checks of these same three oils in the outboard motor proved that the outboard would operate satisfactorily on SAE 30 or SAE 40, but would not accept SAE 50 oil. Therefore, it was evident that the dual purpose oil would have viscosity as specified by an SAE 40 specification.

Fig. 14 shows the results of the test using SAE 50 weight oil with five per cent additive detergent, but having the oil mixed with fuel to the ratio of 40 parts of fuel to one part of oil by weight. It is felt that the appearance of these parts confirms the analysis outlined above that distillation of the fuel from the fuel-oil mix is very complete and that the lubrication of

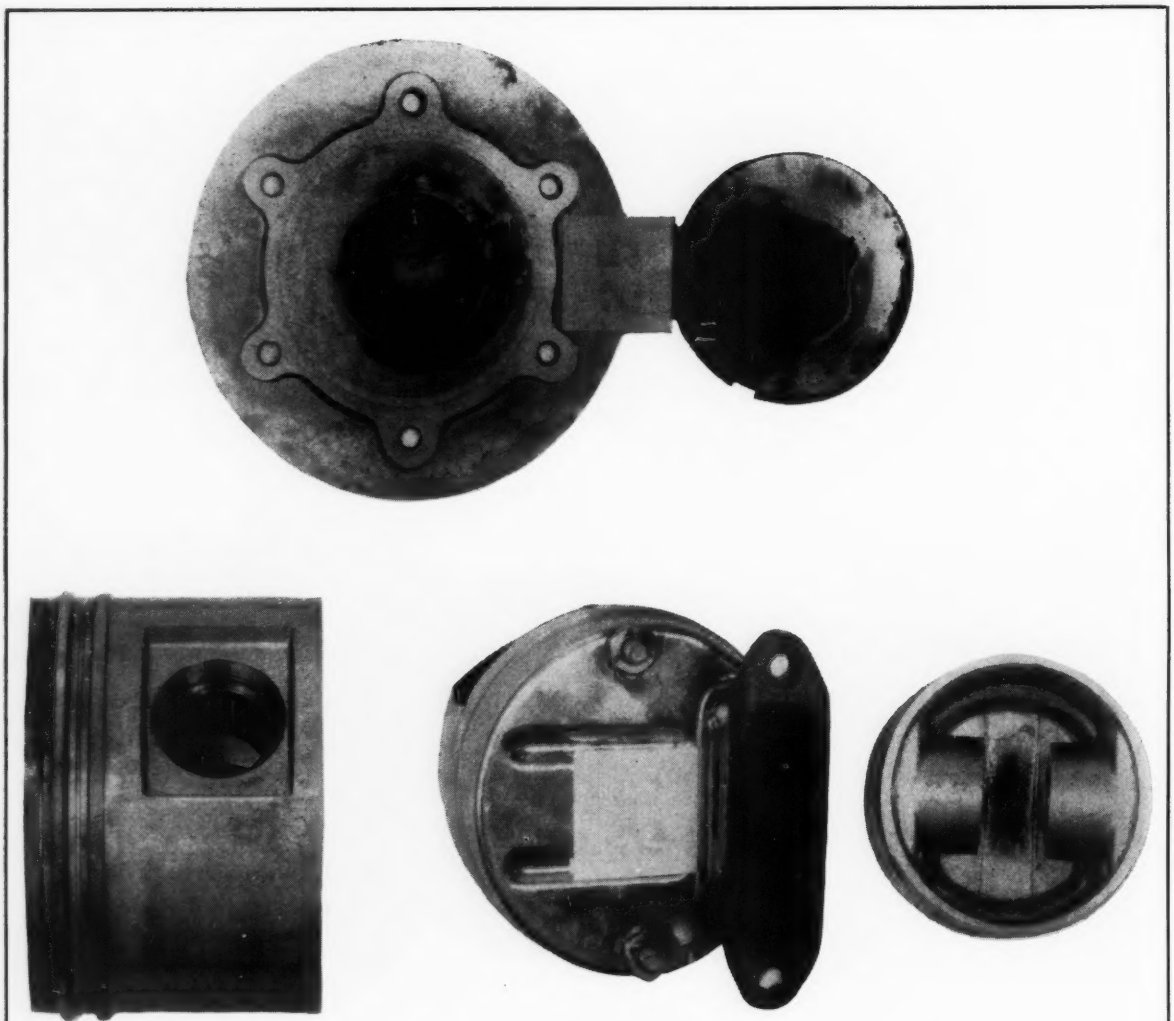

Fig. 12. Chain saw engine parts with new dual engine lubricant—oil screening run #25.

Outboard and Chain Saw Oil "B"
Plus 5% Ashless Detergent
100% Paraffin Base SAE 40
SUS @ 100—867
SUS @ 210—77.5
Viscosity Index—85
Carbon Residue %—.19
Gravity °API—26.7
Flash Point °F—475
Pour Point °F—0
Test run in clean chain saw engine, five min. @ 5000 rpm W.O.T. (max. torque), 15 min. @ 2200 rpm idle, 25 hr. total time. Automotive regular fuel. Fuel-oil ratio 20/1 (wt).

the engine parts is a result of the oil characteristics only and not of its concentration in the fuel-oil mixture.

One of the results of the tests during this project for which a satisfactory explanation has not been found is that the lubricants with viscosity index above 115 do not satisfactorily lubricate the connecting rod bearings, but in many cases result in failed connecting rod bearings. This became evident during some tests of the oils screened by the chain saw engines and being run in the outboard engines. Each time a particular oil was run in the outboard engine, a failed connecting rod bearing resulted. The particular oils involved were SAE 30 weight with a viscosity index of 125, and it was theorized that they had a minimum allowable viscosity at the low temperature; and that even though the viscosity index was high, the viscosity and film strength at the operating temperature were not sufficient to lubricate the connecting rod bearings.

CONCLUSION

The amount of work that has been completed is very small in comparison with the work that should be done before specifications are written for a typical

two-stroke cycle engine lubricant. In order to have a starting place for lubrication engineers and those connected with the refining and blending industry, basic specifications will be listed below. It is hoped that those who have more facility and time for this phase of the problem will expand the specifications and correct them if necessary until the owner of a two-stroke cycle engine can feel secure in purchasing a lubricant designated especially for these engines.

1. Base oil—Solvent refined.
2. Viscosity—SAE 40.
3. Viscosity index—40 to 95.
4. Additive—three per cent to five per cent of an ashless detergent.

This table of specifications is over simplified because of lack of knowledge. It should be amplified by the lubrication people interested to include specifications on corrosion resistance, film strength, carbon residue, neutralization number, and any of the other conditional specifications which might be desirable and necessary to completely specify a satisfactory lubricant. Oils can be satisfactorily refined by methods

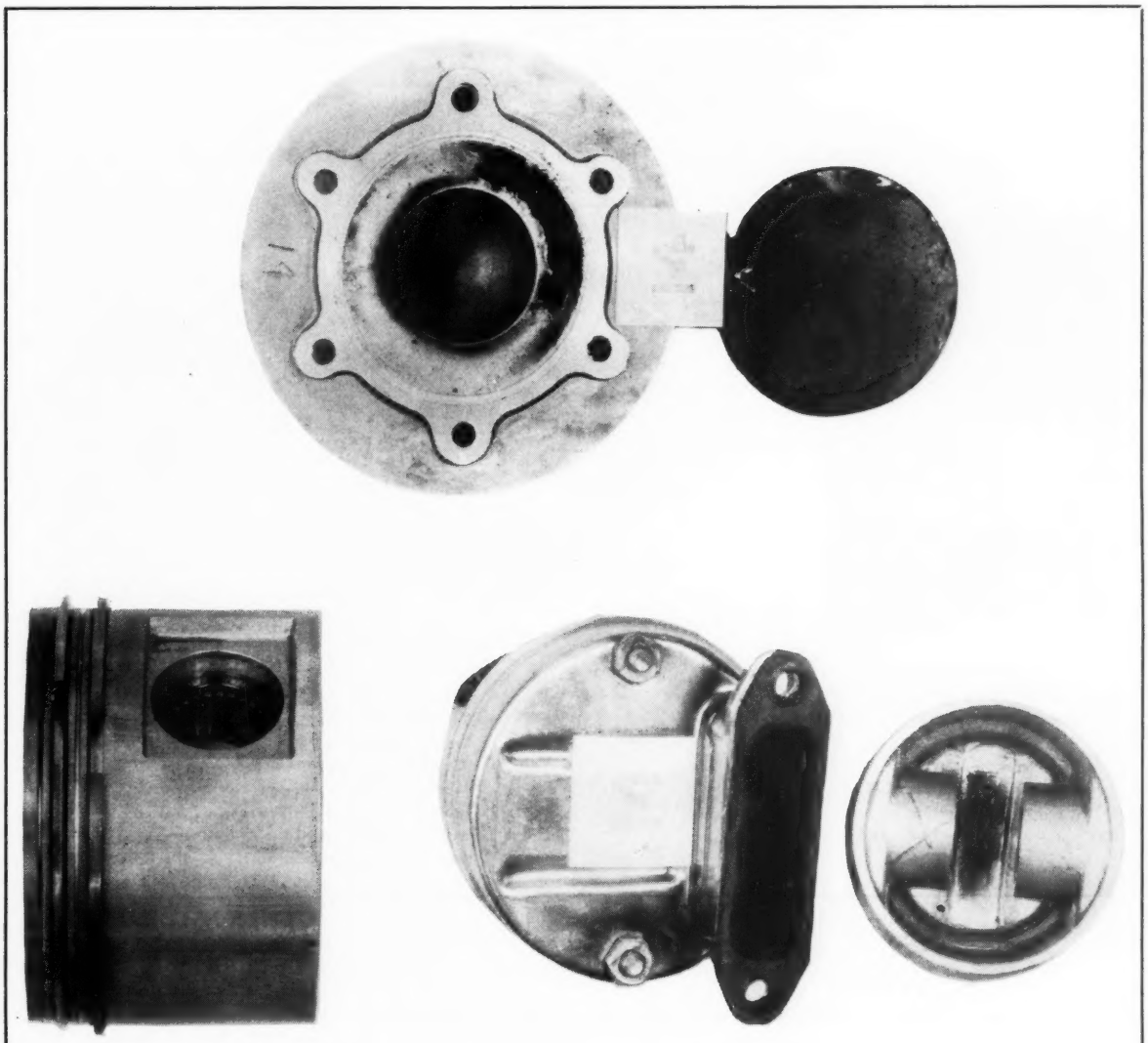

Fig. 13. Chain saw engine parts with sample chain saw oil "C" mixed at fuel-oil ratio of 20/1—oil screening run #14.

Chain Saw Oil "C"
Plus 5% Ashless Detergent
100% Paraffin Base SAE 50
SUS @ 100—1350
SUS @ 210—97.5
Viscosity Index—84
Carbon Residue %—.25
Gravity °API—25.8
Flash Point °F—500
Pour Point °F—5
Test run in clean chain saw engine, five min. @ 5000 rpm W.O.T. (max. torque), 15 min. @ 2200 rpm idle, 25 hr. total time. Automotive regular fuel. Fuel-oil ratio 20/1 (wt).

Fig. 14. Chain saw engine parts with sample chain saw oil "C" mixed at fuel-oil ratio of 40/1—oil screening run #20.

Chain Saw Oil "C"
Plus 5% Ashless Detergent
100% Paraffin Base SAE 50
SUS @ 100—1350
SUS @ 210—97.5
Viscosity Index—84
Carbon Residue %—.25
Gravity °API—25.8
Flash Point °F—500
Pour Point °F—5
Test run in clean chain saw engine, five min. @ 5000 rpm W.O.T. (max. torque), 15 min. @ 2200 rpm idle, 25 hr. total time. Automotive regular fuel. Fuel-oil ratio 40/1 (wt).

other than solvent extraction, and, as time goes on, detergents other than those tested will prove better. The surface has only been scratched in the work that can be done, and it remains for all those interested and concerned to forward the work to its ultimate conclusion.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of the following associates, all of McCulloch Corporation, in the preparation of this paper:

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DISCUSSION of Haas Paper

by D. C. Bardy
Lubrizol Corporation

Haas is to be complimented on a very interesting paper. His data on the mechanism of lubrication are very informative. The distillation of fuel from the fuel-oil mixture and its effect on the lubrication of two-cycle engines are clearly shown.

Based on our experience we agree with Haas on the following points:

(1) Air-cooled engines are more difficult to lubricate than water-cooled engines.
(2) The chain saw is an excellent tool for screening two-cycle lubricants.
(3) An SAE 40 oil, viscosity index of 50 to 95, represents a good compromise for use in both air-cooled and water-cooled engines.

We cannot agree with the following impressions Haas leaves in his discussion of Lubricants and Additives.

(1) Metallic or Ash-containing additives produce excessive plug fouling, exhaust port deposits, and heavy piston crown deposits. These deposits may lead to piston burning through preignition.
(2) We cannot agree that ashless detergents eliminate these deposits.

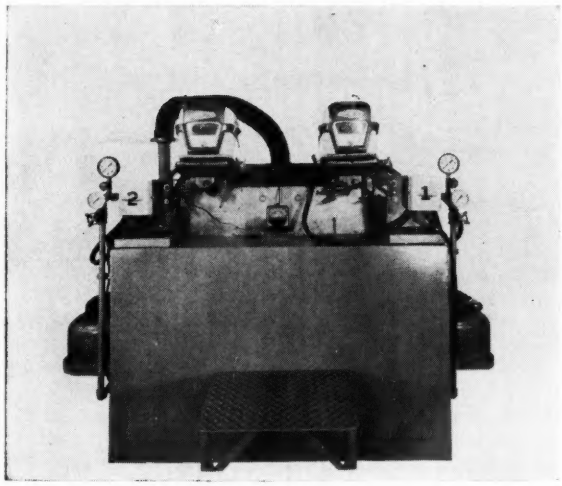

Fig. A1. 35 HP outboard motors.

The following data have been gathered from our laboratory tests. They will show that general statements, as to performance, cannot be made about additives as a group. After classifying additives as either ash-containing or ashless, one still cannot predict their performance in a two-cycle lubricant.

Let us consider deposit build up in a 35 HP outboard motor. These engines operate for 275 out of 300 hours at full load and full throttle conditions.

Fig. A2 shows the total number of plugs fouled versus test hours. The following conclusions are evident:

A given induction period is necessary before combustion chamber deposits stabilize. For this test it takes 50 to 100 hours before the rate of spark plug fouling becomes constant. A test of less than 100 hours under these conditions would not necessarily show differences between oils with respect to plug fouling or combustion chamber deposits.

The base oil alone produced more spark plug fouling than did the base oil plus two per cent by volume of

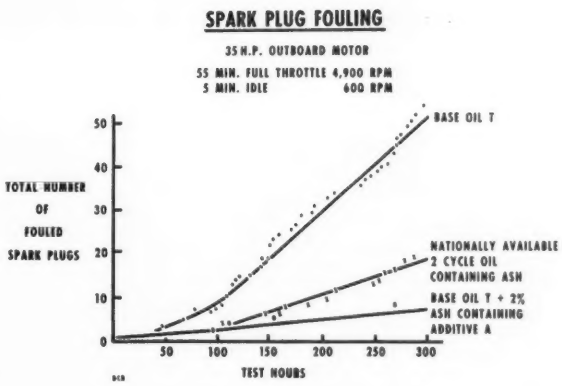

Fig. A2. Spark plug fouling, 35 HP outboard motor tests.

Additive A. By adding this ash-containing additive to the base oil plug fouling was reduced by 85 per cent. A nationally available ash-containing, two-cycle oil also produced fewer fouled plugs than did the base oil. This oil is recognized as a satisfactory product by a large outboard motor manufacturer. A corresponding improvement was shown in piston cleanliness.

Fig. A3 shows the pistons taken from this series of tests.

Over 4,000 hours of engine testing under these conditions have failed to produce any evidence of preignition or piston burning. The majority of the oils tested contained carefully selected ash-containing, two-cycle additives.

Next let us consider data taken from the chain saw engines.

These engines are bolted to a base placed over the top of a 55-gallon drug, three-fourths filled with hydraulic oil. The engine drives a gear oil pump through a short drive shaft. The pump sucks oil from the drum, pumps it through a pressure regulator, and discharges back into the drum. The load is controlled by a discharge valve. The test conditions are as follows:

TABLE 1

Throttle Setting:	Adjusted to obtain speed and load
Speed:	4500 RPM
Load:	60 pounds per square inch, gauge pump outlet pressure
Air-Fuel Ratio:	13.0–13.5 to 1
Fuel-Oil Mixture:	20 to 1
Fuel:	Regular gasoline approximately 1.8 ml/gal TEL
Exhaust-Back Pressures:	1 inch Red Oil
Length of Test:	Until load and speed cannot be maintained at full throttle conditions due to exhaust port plugging

We will consider spark plug fouling, exhaust port plugging, and piston cleanliness data taken from these tests.

Two base stocks were used:

(1) Base Stock M, an SAE 50 mid-continent oil of 93 VI. This oil is marketed by a prominent chain saw manufacturer.
(2) Base Stock T, an SAE 50 mid-continent oil of 89 VI.

Nine different additive formulations containing such elements as barium, calcium, magnesium, and zinc were run at an equivalent ash level. Seven different ashless formulations containing both commercial and experimental additives were

Fig. A3. Pistons from 35 HP outboard motor tests.

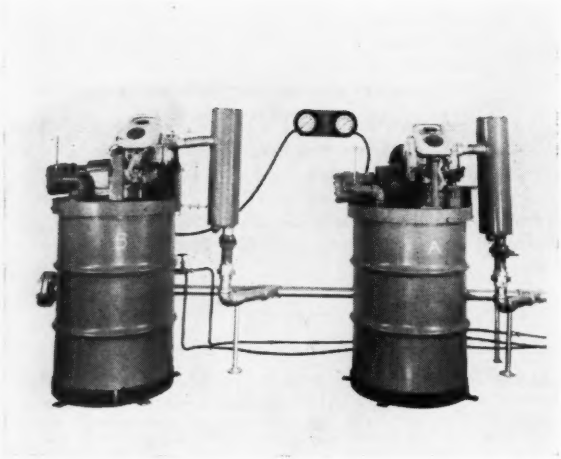

Fig. A4. Chain saw engines.

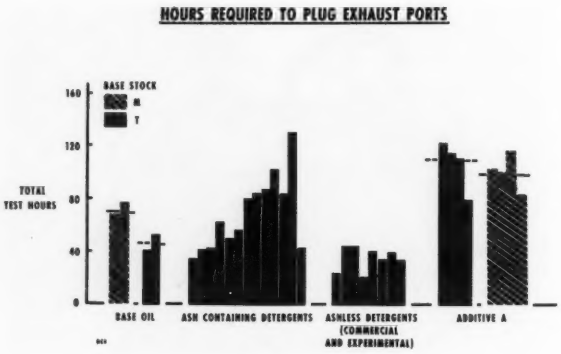

Fig. A6. Exhaust port plugging, chain saw engine.

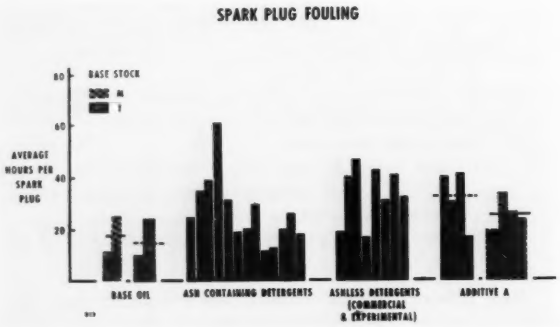

Fig. A5. Spark plug fouling, chain saw engine.

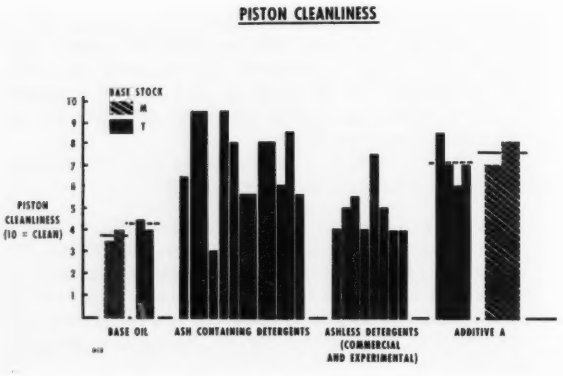

Fig. A7. Piston cleanliness, chain saw engine.

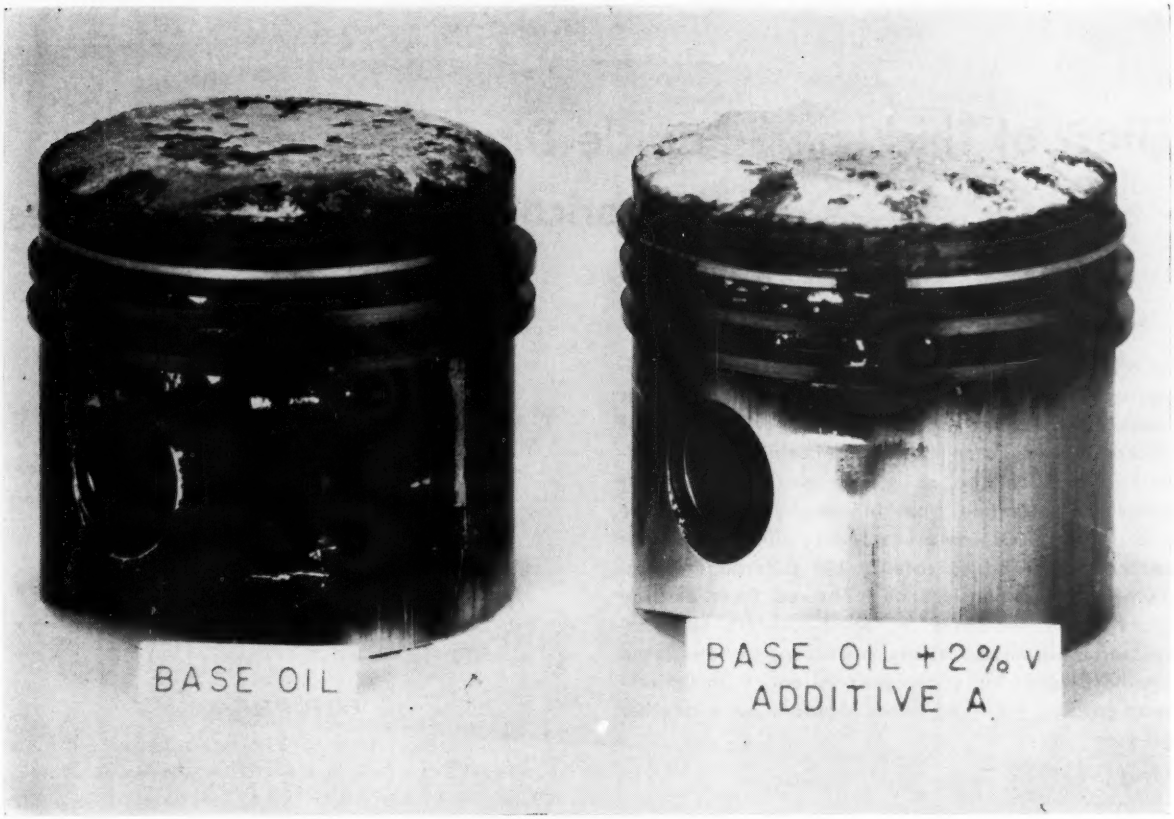

Fig. A8. Pistons from chain saw engine tests.

used at 2 per cent to 5 per cent by volume. A commercial ash-containing, two-cycle oil treatment, Additive A, was also added to the base stock at 2 per cent by volume.

In Fig. A5 we compare spark plug fouling.

The base oils had an average plug life of 17 hours. In Base Stock T the various ash-containing oils gave plug life ranging from 12 to 61 hours, and the ashless detergents gave plug life ranging from 16 to 53 hours. In these comparisons note the range in results with both the ash-containing group and the ashless group. Both base stocks when treated with Additive A, increased average plug life by seven and 16 hours, respectively. Each bar represents a single test. The last comparison was run four times for each oil.

Fig. A6 compares exhaust port plugging. All tests were run until the engine could no longer maintain speed and load at full throttle due to excessive exhaust port plugging.

Without additives Oil M shows a definite advantage over Oil T, the average test life being 73 versus 47 hours. The various ash-containing oils range in test hours from 32 to 131 hours. The ashless detergent oils range in test hours from 16 to 47 hours. The over-all performance of the ashless detergents in these tests is shown to be no better than the base oil alone.

Both base stocks when treated with Additive A increased their average test life to 102 and 108 hours. It is interesting to note that the response of the poorer base stock, Oil T, was greater than that of Oil M; resulting in a comparable finished product.

In examining Fig. A7 bear in mind that the ash-containing oils averaged 70 hours per test, while the ashless detergent oils averaged only 35 per test. All things being equal, a shorter test should produce a cleaner piston.

Both base oils produced pistons with ratings of about 4.0, ten being clean. The ash-containing oils had piston ratings ranging from 4.5 to 7.5. The two base oils, when treated with Additive A, had piston ratings of about 7.5.

Fig. A8 shows two chain saw pistons.

One was run with base oil and the other with base oil plus ash-containing Additive A. This degree of improvement in piston cleanliness is typical for this treatment.

I would like to urge the author not to apply too many generalities when defining an acceptable two-cycle lubricant. The final proof of a lubricant lies in how it performs in a variety of two-cycle equipment under various operating conditions. It is even possible to obtain a wide range in performance between different additive formulations containing the same basic elements. Broad definitions of acceptability will only include and promote many inferior products. They will exclude some products designed to improve the performance of two-cycle lubricants.

It may be wise not to classify oils in broad general categories as to type of treatment. However, if specifications are desirable, practical test standards for evaluating the final product under conditions similar to those encountered in the field may prove to be a more realistic approach.

Editor's Note:

Authors are furnished a copy of each discussion and invited to submit a closure. Since no closure was submitted for the above article, it may be assumed that the author either concurred with the discussor or did not feel that a reply was necessary.

Effect of Thickener–Particle Dimensions on Lubricating–Grease Properties

One of the factors affecting properties of lubricating grease is the size and shape of the thickener particles. The effect of the length-to-width ratio of thickener particles on mechanical stability, age-hardening, and leakage of grease was studied. Four greases were made from lithium hydroxy stearate and a mineral oil. The greases were alike in thickener concentration and consistency but differed in thickener-particle dimensions as measured from electron micrographs. Increases in length-to-width ratio increased mechanical stability and leakage and reduced age-hardening. Although observed only with lithium-soap greases, the same trends should occur with other greases.

by A. C. Borg and R. H. Leet
Standard Oil Company, Whiting, Indiana

Research on the nature of lubricating grease has mainly involved physical-chemical studies of structure and empirical tests of gross properties. Structure studies have shown that grease consists of a two-phase system of solid thickener particles dispersed in oil. Tests of properties have defined changes that greases undergo during working and storage. To place grease development on a scientific basis, grease properties should be better understood in terms of structure.

The thickener phase of lubricating grease consists of randomly dispersed particles (1, 2) that have been measured from electron micrographs. Because the particles of most thickeners are long rods, threads, or fibers, the shape has usually been expressed as the average length-to-width ratio. This ratio becomes smaller when a grease is sheared, because of breakage of the fibers, and often appears to increase when the grease is left undisturbed. These changes have been correlated with changes in consistency (3), but not with other grease properties.

The effect of changes in particle size on mechanical stability, age-hardening, and leakage was measured. Greases of the same composition and consistency but varying in particle dimensions were studied. Each grease was tested in standard laboratory apparatus, and electron micrographs were made of appropriate samples.

Presented before the 14th ASLE Annual Meeting, April, 1959.

EXPERIMENTAL

Four greases were made of seven per cent lithium 12-hydroxy stearate in a solvent-extracted oil having a viscosity of 100 ssu at 100 F, and a Viscosity Index of 55. Different methods of preparation were used to make greases of the same consistency, but with thickener particles of different average length-to-width ratio, (L/W). The L/W ratios of the unworked greases were 13, 17, 22, and 31; they were used to identify the greases. Electron micrographs of the four greases are shown in Fig. 1.

Mechanical stability was measured by the change in penetration before and after working in both the ASTM worker and the roll-stability apparatus. The ASTM worker was operated according to Method D 217-52T except that a plate with 1/16-inch holes was used. The roll-stability apparatus (4) was operated at 160 rpm with a 90-gram charge of grease. Consistency was measured with the ASTM quarter-scale cone penetrometer (5); a correlation curve converted results to ASTM penetrations. Age-hardening was measured as the change in penetration upon aging 1500 hours. All working and subsequent aging was at 77 $\pm$ 2 F, with a relative humidity of 3 per cent. Leakage tendency was evaluated by the amount of oil lost from each grease under the stress of moderate pressure on an unworked sample (6).

Each grease was divided into three groups of five samples each. One group was placed in penetrometer cups unworked, the second was first worked 100,000 strokes in the ASTM worker, and the third was worked four hours in the roll-stability apparatus. Penetrations and electron micrographs were taken on a sample from each group after five scheduled periods of aging at room temperature over a total of 1500 hours. Average L/W ratios were determined from electron micrographs by measuring at least 500 fibers for each sample. The method used is repeatable within five per cent (3).

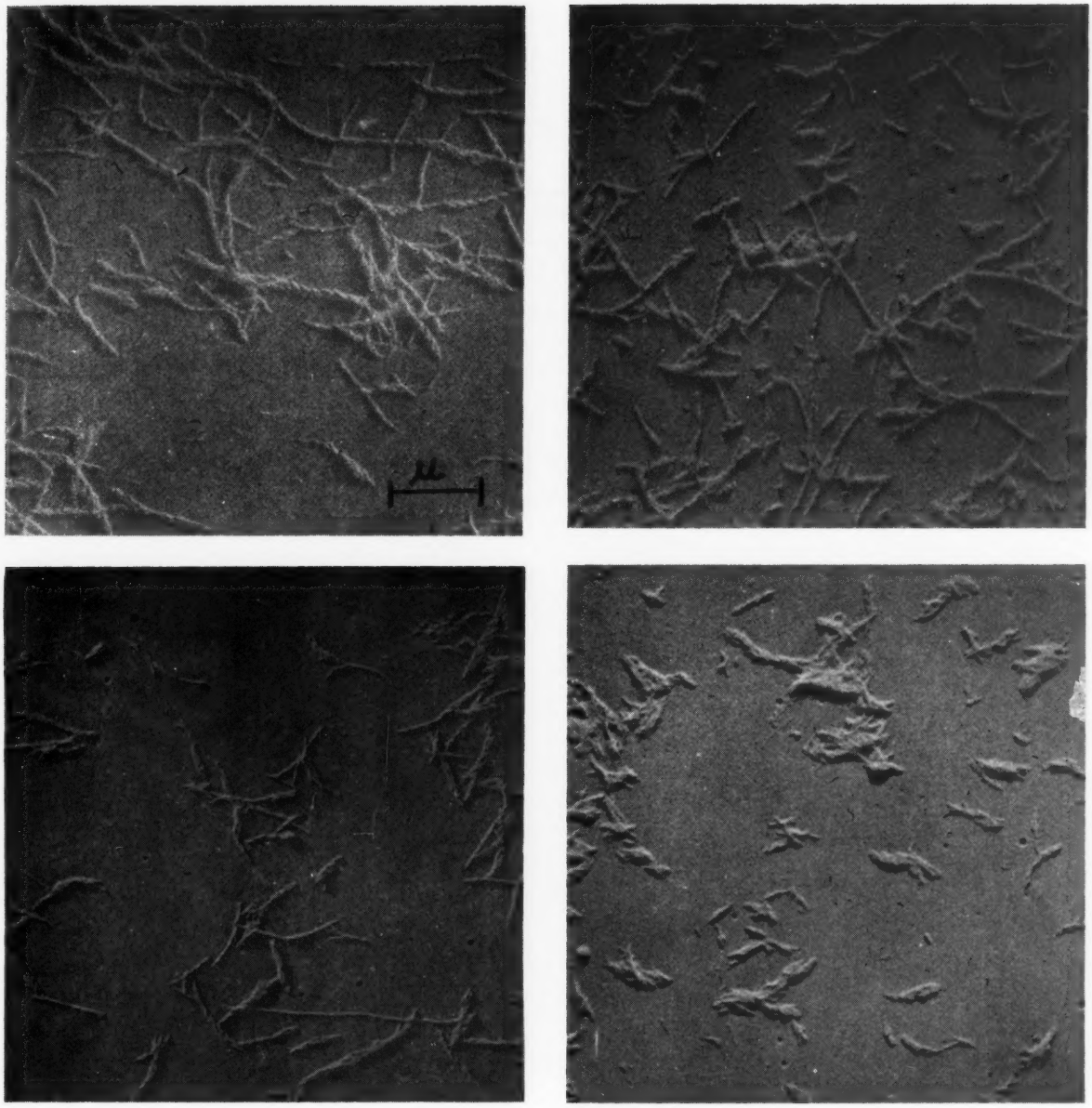

Fig. 1. Electron micrographs of greases.

RESULTS

All four greases changed similarly in consistency upon working and aging. As shown in Fig. 2, working caused softening or an increase in penetration, and subsequent aging always resulted in hardening or a decrease in penetration. Hardening was rapid in the first few hours after manufacture or working but leveled out at about 1000 hours.

Mechanical stability increases with L/W ratio, as shown in Fig. 3. Upon working in the ASTM worker, mechanical stability increased with each increase in L/W ratio. Data from the roll-stability apparatus show more scatter but indicate the same trend.

Age-hardening decreases with increase in L/W ratio, as shown in Fig. 4. The data represents Greases 13, 17, and 22 unworked (circles) and previously worked in the ASTM worker (squares) and roll-stability apparatus (triangles). Thus, three points were obtained for each grease. Although Grease 31 was not aged beyond 750 hours, Fig. 2 suggests that it would fit the behavior pattern indicated in Fig. 4.

Leakage increased with L/W ratio, as shown in Fig. 5. Although Grease 31 showed slightly less leakage than Grease 22, both were well beyond the 7.5 per cent limit of significance of the pressure test.

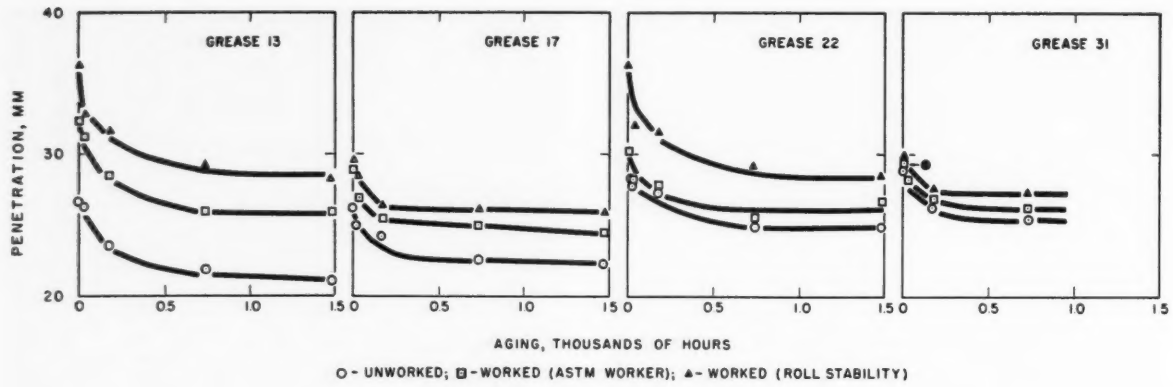

Fig. 2. Consistency change during aging.

DISCUSSION

The relation between L/W ratio, mechanical stability, and age-hardening results from the influence of particle shape on changes in grease structure during working and aging. Because the greases contained the same amount of soap and the particle widths were nearly constant, greases with the largest L/W ratio contain the largest particles and the fewest per unit volume. Greases with the largest particles also have the largest and fewest interstices in the fiber network. Hence the effect of L/W ratio on grease properties for these greases can be explained in terms of the number of particles per unit volume.

During working, greases soften because the network is broken by disruption of particle-to-particle forces, and some individual particles are broken. Working can also lead to more-uniform distribution

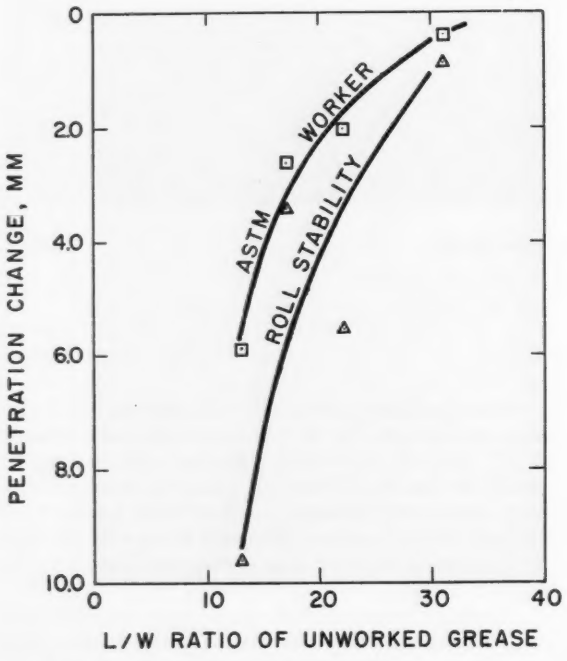

Fig. 3. Effect of L/W ratio on mechanical stability.

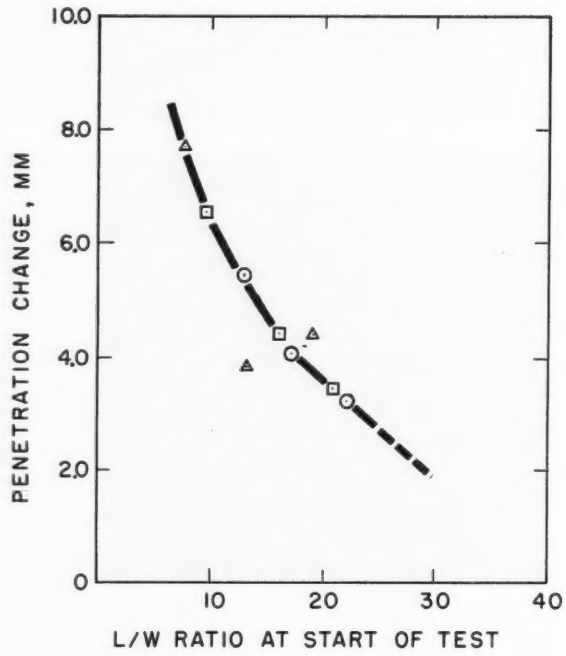

Fig. 4. Effect of L/W ratio on age-hardening.

of particles, which would cause hardening. Thus, the softening measured by consistency changes is the net result of contrasting effects. Inasmuch as the grease with the fewest particles per unit volume was the most stable during working, disruption of the network rather than particle breakage was the primary cause of softening in the laboratory tests.

During aging, greases harden because the network can reform by reconstituting interparticle forces. Also, evidence of particle growth has been found (3). Because the grease with the largest number of particles per unit volume age-hardened the most, reconstitution of interparticle forces was the primary cause of age-hardening.

Leakage of oil occurs because the oil is incompletely held in the interstices of the thickener network by capillary forces. As would be expected, the grease with the smallest interstices showed the least leakage.

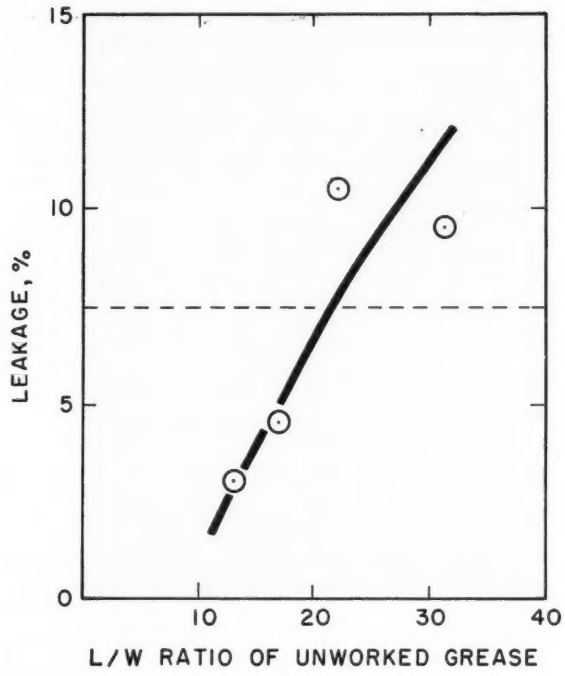

Fig. 5. Effect of L/W ratio on leakage.

CONCLUSION

Of the many structural factors influencing the properties of lubricating greases, the effects of L/W ratio are now better understood. Although the curves can be directly applied only to the lithium-soap greases studied, the same trends should apply to other greases with different thickeners. Further work should be done to establish curves for other greases.

Other structural parameters should also be studied. Measurements of interaction energies between particles could undoubtedly be related to mechanical stability and age-hardening. The uniformity of distribution of thickener particles should be related to leakage tendency. The strength of thickener fibers should be related to mechanical stability. Not until such studies are completed can the best greases be developed on a truly scientific basis.

ACKNOWLEDGMENT

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DISCUSSION of Borg and Leet Paper

by J. Panzer

The paper by Borg and Leet represents an excellent and much needed contribution towards understanding the behavior of grease systems. Their work is very important since it offers experimental facts reported in this paper and some of the current theories concerning the behavior of colloidal systems. We would like to comment on several questions that arise upon reading this paper, and then discuss some of our own research which bears upon these questions.

The work in the paper which is under discussion attempts to explain some practical test observations made on a group of greases in terms of a fundamental property of these greases, the particle size of the thickener. Since it is suggested that the relationships found for the lithium greases may apply to other grease systems, one may ask whether the lithium hydroxystearate is a typical grease thickener and whether the soap content and base oil are realistic and representative of those found in most greases. We feel that the answer to all these questions is "yes" and that for this reason the results are important and valuable to the grease technologist who would like to know what makes greases behave as they do.

Similarly, one may question the techniques used for studying the greases. For example, is electron microscopy the best way for studying the particle size of grease thickeners? Here again there is considerable evidence showing that among the numerous techniques available, the most suitable one has been chosen. Although there are difficulties in measuring the individual L/W ratios because the grease particles overlap each other, this method is the most precise one we know for measuring particle sizes and their distribution, and we have used it extensively in our own work.

No comment needs to be made on the ASTM worker test or the leakage test since these are fairly straightforward grease tests, widely accepted and highly reproducible. We do, however, question the usefulness of the roll-stability test. Our experience with this test indicates its reproducibility fluctuates from time to time and that very small variations in environmental conditions or in the way in which the test is conducted can affect the results markedly.

Before discussing our work and its relation to that of Borg and Leet, we would like to comment on the relationship between the consistency and particle size of lithium greases. Although the four greases examined in the paper under discussion have the same initial unworked penetration with respect to the NLGI classification of grease systems, the actual values vary from 260 to 285 mm/10. This variation is not great but appears to be as significant as the variation in the L/W ratios of the four greases. This observation is consistent with the fact that the lower the L/W ratio, the greater the surface area of the particles, and hence the larger the number of interparticle contacts, leading to a harder grease. It would be interesting to determine what relationships existed if the greases were compared at identical consistency, while varying the thickener content.

We have found in our study of a calcium grease system that as the particle size decreases, the consistency increases, the degree of breakdown on shear increases, the separation of oil from the system decreases, and the relative change in consistency on aging increases. This agreement with the relation-

TABLE 1. CALCIUM ACETATE DIHYDRATE SUSPENSIONS PARTICLE SIZE DISTRIBUTION, %

BLEND	1 − 5μ × 0.05 − 0.1μ	0.1μ × 0.01μ
a	80.0	20.0
b	66.6	33.4
c	50.0	50.0
d	44.3	55.7
e	26.9	73.1

TABLE 2. CALCIUM ACETATE DIHYDRATE SUSPENSIONS PROPERTIES

BLEND	VISCOSITY, CPS.	SHEAR BREAKDOWN, VIS @ 6 RPM/ VIS @ 30 RPM	SUSPENSION STABILITY
a	1600	2.03	1.30
b	2360	2.34	1.80
c	2660	2.50	2.40
d	4780	2.68	2.66
e	6880	2.75	3.00

TABLE 3. CALCIUM ACETATE DIHYDRATE SUSPENSIONS EFFECT OF PARTICLE SIZE AT CONSTANT VISCOSITY

BLEND	VISCOSITY, CPS.	CONC. ACETATE, %	SHEAR BREAKDOWN	SUSPENSION STABILITY
a_1	840	6.7	1.75	1.52
b_1	860	6.7	1.61	2.18
e_1	800	3.3	1.77	3.58
b_2	520	3.3	1.50	1.88
e_2	520	1.7	1.59	3.88
b	2360	10.0	2.34	1.80
e_3	2460	6.7	2.38	3.98

TABLE 4. CALCIUM COMPLEX GREASES PARTICLE SIZE VS. PROPERTIES

PARTICLE SIZE DISTRIBUTION, % L/W = 2 − 8 L/W = 10 − 100 LENGTH, μ 0.1 − 0.2	1 − 3	VISCOSITY, POISES	SHEAR BREAKDOWN	OIL BLEEDING, %
28	72	140	Little	6.2
42	58	153	Moderate	3.2
50	50	200	Great	3.1

ships developed by Borg and Leet is all the more interesting because the thickener is entirely different from a lithium soap.

In Table 1 are shown the particle size distributions for five semi-fluid calcium acetate-dihydrate suspensions in mineral oil listed in order of decreasing average particle size. These suspensions, which were prepared to study the effects of particle size on grease properties, consist of ten per cent solids in a naphthenic oil with a viscosity of 55 sus at 210 F. It was found that the particles in these suspensions fell within two particle size classifications with the relative distribution different for each semi-fluid product. Each distribution was determined from measurements of at least 400 particles appearing in electron micrographs.

On Table 2 are presented the viscosity, shear breakdown, and suspension stability of the same five suspensions. The viscosity (or consistency) was measured at 77 F by a Brookfield viscometer (Model LVF) with a number 3 spindle at 6 rpm. The shear breakdown or change in apparent viscosity with increasing shear rate (comparable to the change in penetration on working a grease) is indicated as the ratio of viscosities at 6 and 30 rpm. The suspension stability or tendency of oil to separate from the system was determined by centrifuging the samples at 1500 rpm for four hours. Suspension stability numbers in the table are calculated by dividing the volume per cent of the original suspension remaining after oil separation by the concentration of the solids. Thus, the higher the number obtained, the less the oil separation. Although the data for the change in viscosity on aging are not shown, it was qualitatively observed that as particle size decreased, the relative increase in viscosity was greater. As we go down each column in the table we see that the viscosity, shear breakdown, and suspension stability (the inverse of oil separation) all increase as particle size decreases.

In addition to the above findings, it was of interest to learn what the effect of particle size on properties would be if only products of the same viscosity were compared. This was done by diluting with oil some of the five semi-fluid suspensions to several levels of viscosity, and determining the shear breakdown and suspension stability as before. The data in Table 3 show that at three viscosity levels, the same relationships hold true. Within each group of suspensions the shear breakdown is constant regardless of particle size, while separation of oil decreases as the particle size decreases.

The discussion up to this point has dealt with suspensions that are not commercial products but which were prepared as part of a basic study of particle size and grease properties. Another study of the same kind was performed on calcium complex greases which are commercial products, with similar results having been obtained. Table 4 shows that as the particle size decreases, the viscosity increases, shear breakdown increases, and the oil bleeding decreases, as found for both lithium stearate and calcium acetate systems. The shear breakdown data are not indicated quantitatively on the table because this information is based on the approximate areas of the stress-strain hysteresis loops obtained with the greases in a platecone viscometer.

It thus appears that the relationships found for lithium greases apply to other grease systems. If this situation is generally true, it means that, once we take into consideration the basic contribution of the thickener-fluid system, the effects of changing particle size, shape, distribution, and concentration are strictly physical and that simple particle/fluid models ought to work in theoretical calculations. To establish whether this is so and to develop a more complete understanding of the rheology and stability of grease systems, further work will be needed in extending the above relationships to other grease systems and to grease properties other than those which have been studied.

Editor's Note:

Authors are furnished a copy of each discussion and invited to submit a closure. Since no closure was submitted for the above article, it may be assumed that the authors either concurred with the discussor or did not feel that a reply was necessary.

The development of the solid railway journal bearing is traced from its early development.

The major design changes of 1942 are evaluated by comparing two surveys of scrap bearings, one made by the AAR in 1945, and a recent one made by the author. The design changes appear to have substantially changed the pattern of end wear.

Two other recent surveys of scrap bearings show conclusive evidence of undesirable bearing load distribution. Many bearings are more heavily loaded at one end or at both ends than in the middle where the oil film would be best able to carry the load.

The designs of recent experimental bearings which have been field tested are discussed. An additional experimental design is proposed for field testing.

Developments in Railroad Journal Bearings

by M. A. Hanson

Magnus Metal Corporation, Chicago, Illinois

To those not thoroughly familiar with the development of the solid journal bearing, the various design details do not appear significant or to bear any particular relationship to service performance. Most of the design details have developed through an evolutionary process over a period of years. In most instances the changes have been based on extensive service performance tests.

Prior to the foundation of the Master Car Builders Association in 1867, railroad cars and car components were built by the individual railroad without any organized reference to others engaged in the same work.

The most extensively used bearing of the period was the iron cased bearing, which consisted of an oblong box with a curved top to give the necessary lateral rocking motion as shown in Figs. 1 and 2. The inside of the case was filled with babbitt. Anchor grooves were provided to hold the babbitt in place. The exact composition of the babbitt varied according to the experience of the particular user. The bearing was applied without a wedge and made direct contact with the journal box roof.

At the first meeting of the Master Car Builders Association, the matter of a standard axle and bearing for passenger cars was discussed. In 1869 the recommendation was made to adopt as standard for passenger and sleeping cars an axle with a 3-¾ inch x 7 inch journal. Soon thereafter the first major bearing design change occurred. The bearings were made with sloping sides and the use of a wedge was introduced to provide greater flexibility. The journal boxes were provided with stop bars cast integral with the box and lugs were added to the journal bearing to regulate the lateral movement on the journal. Thus, the general shape of the bearing of 1870 quite closely resembles the present bearing.

The Master Car Builders standard 3-¾ inch x 7 inch bearing of 1869–1881 was cast with a 40 inch radius lengthwise from the collar to lug end. This design was continued until 1893 at which time a 78 inch radius was provided on the wedge instead of the bearing. In 1889 the Master Car Builders had recommended the adoption of a 4-¼ inch x 8 inch flat back bearing and the use of a 78 inch radius wedge for 60,000 lb capacity cars. The use of the 78 inch radius wedge was continued until 1958, at which time a 50 inch radius was adopted. This change was made on the basis of test results obtained during an investigation of load distribution on journal bearings (1).

By 1875 a number of railroads had adopted a brass journal bearing in lieu of the cast iron, babbitt filled bearing. The brass bearings were generally unlined, but a self fitting bearing had been patented in 1870. A lead sheet was placed between the brass bearing and the journal which molded itself to conform

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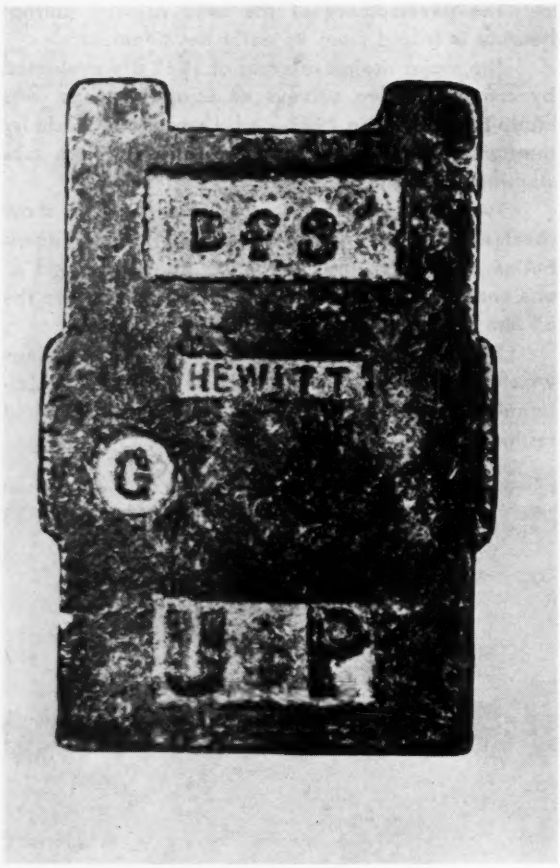

Fig. 1. Top view—iron cased bearing. Photograph courtesy of Union Pacific Railway Museum.

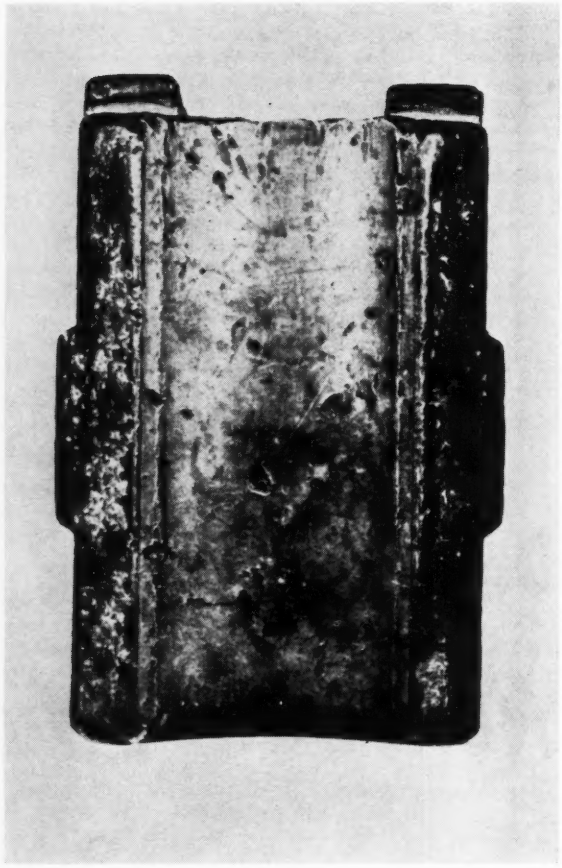

Fig.2. Bottom view—iron cased bearing. Photograph courtesy of Union Pacific Railway Museum.

to the journal. It was known that a lining could be soldered or bonded to the brass back, but this method was not used to any extent until later. The mandatory use of a babbitt lining for journal bearings was not adopted by the Master Car Builders Association as a standard practice until 1915.

The capacity of cars was increased quite rapidly and appropriately larger bearings were adopted as standard. In 1895 a five inch x nine inch bearing was adopted, in 1900 a 5½ inch x 10 inch, in 1914 a 6 inch x 11 inch and in 1920 a 6½ inch x 12 inch.

The first standard specification covering the composition of the bearing back and lining was adopted by the Master Car Builders in 1915. These specifications have been superceded by revised ones formulated by the succeeding governing Associations, namely —the American Railway Association, Mechanical Division, and finally by the Association of American Railroads, Mechanical Division.

MAJOR DESIGN CHANGE—1942

In 1942 the design of the standard AAR Journal Bearings was changed quite substantially. The bearing collar profile was changed and the collar thickness increased by 1/16 inch, the length of the bearing was reduced by ¼ inch, the width reduced by ¼ inch, the lugs were relocated, and the lining thickness reduced. A depressed center portion for the bearing back was adopted as an alternate standard. Because of manufacturing difficulties the lining was restored to its original thickness after a few months time.

One of the factors behind the design change of 1942 was the desire to conserve critical metals. The various revisions made resulted in finally reducing the weight of a 5½ inch x 10 inch bearing by approximately one pound. Fig. 3 and Table 1 show the design and dimensions of the pre 1942 bearing, and Fig. 4 and Table 2 show the revision in use since 1953, which is substantially the same as the bearing in use between 1942 and 1953, except for the lug shape.

EFFECT OF 1942 DESIGN CHANGE

To determine the effect these design changes are having upon bearing wear, a survey was recently undertaken during which 10,029 bearings were inspected to determine the causes for them having been scrapped. All of the bearings received in seven carloads of scrap bearings from five different customers were inspected. This represents something over .2 per cent of a year's journal bearing consumption for the entire railroad industry. The data secured was compared with similar data obtained by inspecting 1,274,328 bearings found in the scrap of 25 railroads during the period December 1944 through November

TABLE 1. DIMENSIONS OF PREWAR AAR JOURNAL BEARING WITH DEPRESSED BACK WITH PERMISSIBLE VARIATIONS.

JRL. SIZE	DIMENSIONS IN INCHES																			
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V
5 x 9	2 17/32	8 3/4	5 5/8	3 1/8	5 3/16	1 1/32	1 7/32	1 1/8	2 1/4	6 7/8	1 7/16	11/16	2 1/16	4 7/8	7/8	1/8	3/4	1/8	5/8	3/4	1 1/4
5 1/2 x 10	2 25/32	9 3/4	6 1/8	3 1/8	5 11/16	1 1/16	1 5/16	1 1/8	2 3/8	7 3/8	1 7/16	3/4	2 1/4	5 3/8	7/8	1/8	3/4	1/8	5/8	3/4	1 1/4
6 x 11	3 1/32	10 3/4	7 1/8	3 1/2	6 5/8	1 1/4	1 1/2	1 1/4	2 3/4	8 3/8	1 7/8	13/16	2 7/16	6 1/4	1	1/8	3/4	1/8	5/8	3/4	1 3/8
6 1/2 x 12	3 9/32	11 3/4	7 5/8	4	7 1/8	1 7/16	1 9/16	1 3/8	3	8 7/8	1 7/8	7/8	2 5/8	6 1/2	1 1/8	1/8	3/4	1/8	5/8	3/4	1 11/16
PERMISSIBLE VARIATIONS																					
PLUS	1/32	1/32	1/32	1/32	1/16	1/32	3/64	1/16							1/16		1/16	0	1/32		
MINUS	1/64	1/32	1/32	1/32	1/32	3/64	0	1/32							0		0	3/32	1/16		

TABLE 2. DIMENSIONS OF AAR STANDARD JOURNAL BEARING WITH PERMISSIBLE VARIATIONS PER DRAWING D-24-1957.

JRL. SIZE	DIMENSIONS IN INCHES																						
	A-(DIA)	A-1	A-3	A-5	B	C	D	E	F	G	H	I	J	K	L	M	N	P	R	S	T	U	V
3 3/4 x 7	3.765	3.765			6 1/2	4 1/4	2	4 5/32	7/8	1 1/8	1	2	5 1/2	2 23/32	1 11/16	1 21/32	3 3/4	3/4	1 11/16	2	3 1/8	3 3/8	1/4
4 1/4 x 8	4.265	4.265			7 1/2	4 5/8	2 5/16	4 21/32	27/32	1 9/32	1	2 1/8	5 7/8	2 23/32	1 15/16	1 25/32	4 3/8	3/4	2 1/16	2 1/4	3 5/16	3 7/8	1/4
5 x 9	5.015	5.015	4.890	4.765	8 1/2	5 3/8	3 1/8	5 11/32	1 1/32	1 7/32	1 1/8	2 1/4	6 7/8	3 3/32	2 3/16	2 3/32	4 7/8	7/8	2 7/16	2 1/2	4 1/8	4 3/8	5/16
5 1/2 x 10	5.515	5.515	5.390	5.265	9 1/2	5 7/8	3 1/8	5 27/32	1 1/16	1 5/16	1 1/8	2 3/8	7 3/8	3 3/32	2 1/2	2 9/32	5 3/8	7/8	2 15/16	2 1/2	4 5/8	4 7/8	5/16
6 x 11	6.015	6.015	5.890	5.765	10 1/2	6 7/8	3 1/2	6 25/32	1 1/4	1 1/2	1 1/4	2 3/4	8 3/8	3 31/32	2 11/16	2 15/32	6 1/4	1	3 5/16	2 3/4	5 1/8	5 3/8	3/8
6 1/2 x 12	6.515	6.515	6.390	6.265	11 1/2	7 3/8	4	7 9/32	1 7/16	1 9/16	1 3/8	3	8 7/8	3 31/32	2 13/16	2 21/32	6 1/2	1 1/8	3 1/8	3 1/8	5 5/8	5 7/8	3/8
PERMISSIBLE VARIATIONS																							
PLUS	.031	.005	.005	.005	1/32	1/32	1/32	1/16	1/32	3/64	1/32							1/32					
MINUS	.016	.000	.000	.000	1/32	1/32	1/32	1/32	3/64	0	1/32							1/32					

1945, as tabulated in an AAR report dated May 20, 1946. Many of the bearings inspected in this earlier survey were undoubtedly of the pre 1942 design, since the average bearing service life is more than three years. Table 3 is a tabulation of the data developed by the two surveys.

The difference shown in the pattern of end wear are believed to be significant; namely, the 265 per cent increase in bearings condemned for wear at the collar or 3/4 inch fillet end, and the 40 per cent reduction in those condemned for wear at the lug end. The collar end of the bearing is presently taking the major portion of the end thrust and wear.

This can quite readily be verified by field inspection of new cars after short service mileage. At times the thrust upon the 3/4 inch fillet becomes great enough to seize and tear the babbitt fillet. Fig. 5 is a photograph showing this condition on a new car after 20,414 miles in eight months time. The opposite end of the bearing is shown in Fig. 6. This end has not received any substantial thrust or wear.

The end of the bearing receiving thrust is dependent upon the length of the bearing, the length of the wedge, and the relative lug location. The longer the wedge, the thicker the bearing collar, the further outboard the lugs, and the shorter the bearing, the greater tendency to take thrust upon the 3/4 inch fillet end of the bearing.

It is the opinion of this author a somewhat better distribution of end wear on the bearings would be beneficial. In considering how this may best be accomplished, a lengthening of the bearing by 1/4 inch seems to be indicated. (2) A reduction in the length of the wedge would tend to increase the lateral in the assembly, which is already greater than desirable. The lug location cannot be moved inboard a sufficient amount to accomplish the desired distribution and still be able to apply the bearing to the journal box. Broken collars are not presently a major difficulty, but easily could be if the bearing collar thickness were substantially reduced to change the pattern of end wear.

Tests currently underway at the AAR Research

Department indicate an increase in the radius of the ¾ inch fillet may also be quite beneficial.

A 1100 car set test of modified 5½ inch x 10 inch bearings has been set up by one railroad in cooperation with the AAR. The bearings are ¼ inch longer than standard. The distance from the face of the lugs to the back of the bearing collar is the same as the present standard bearing, i.e. the entire added ¼ inch in length is on the lug end. This lug location may be slightly further outboard than the optimum. The ¾ inch fillet end will still be theoretically somewhat preferentially loaded, but to considerably lesser degree than an AAR standard bearing.

Another 300 car set test of five inch x nine inch bearings of prewar length (¼ inch longer than standard) and with the prewar lug location has been established by a private car line in cooperation with the AAR. This test has been underway for several months. Service performance indicates the expected reduction of thrust on the ¾ inch fillet is occurring. The opposite end may be taking a slightly greater thrust load than is optimum. Probably a ⅛ inch further outboard lug location would be preferable.

At least two other tests of smaller scope are also underway to investigate this same phase of bearing performance.

The 59 per cent reduction in incidence of loose linings as indicated by the data in Table 3 is probably the result of improved manufacturing techniques and the improved bond strength resulting from the addition of zinc to the journal bearing mix in accordance with the revision of AAR Specification M-501, Journal Bearings—Lined, dated January, 1953.

TABLE 3. SCRAP BEARING SURVEY

REASON FOR REMOVAL	AAR 1944-45	1958
	%	%
1. Broken lug	1.14	1.98
Broken collar	0.91	0.82
Broken body	0.50	0.07
	2.55	2.87
2. Worn lug end	4.96	2.91
Worn collar end	9.66	25.57
Worn both ends	14.04	11.25
	28.66	39.73
3. Loose lining	12.98	3.89
Sections broken out		2.10
4. Lining worn thru crown or side only	7.22	—
5. Spread lining	21.01	20.13
6. Not condemnable under rule 66	18.28	23.34
7. Ran hot	9.30	7.89
8. Wire embedded	—	0.05
Total bearings inspected	1,274,328 — 100.00%	10,029 — 100.00%

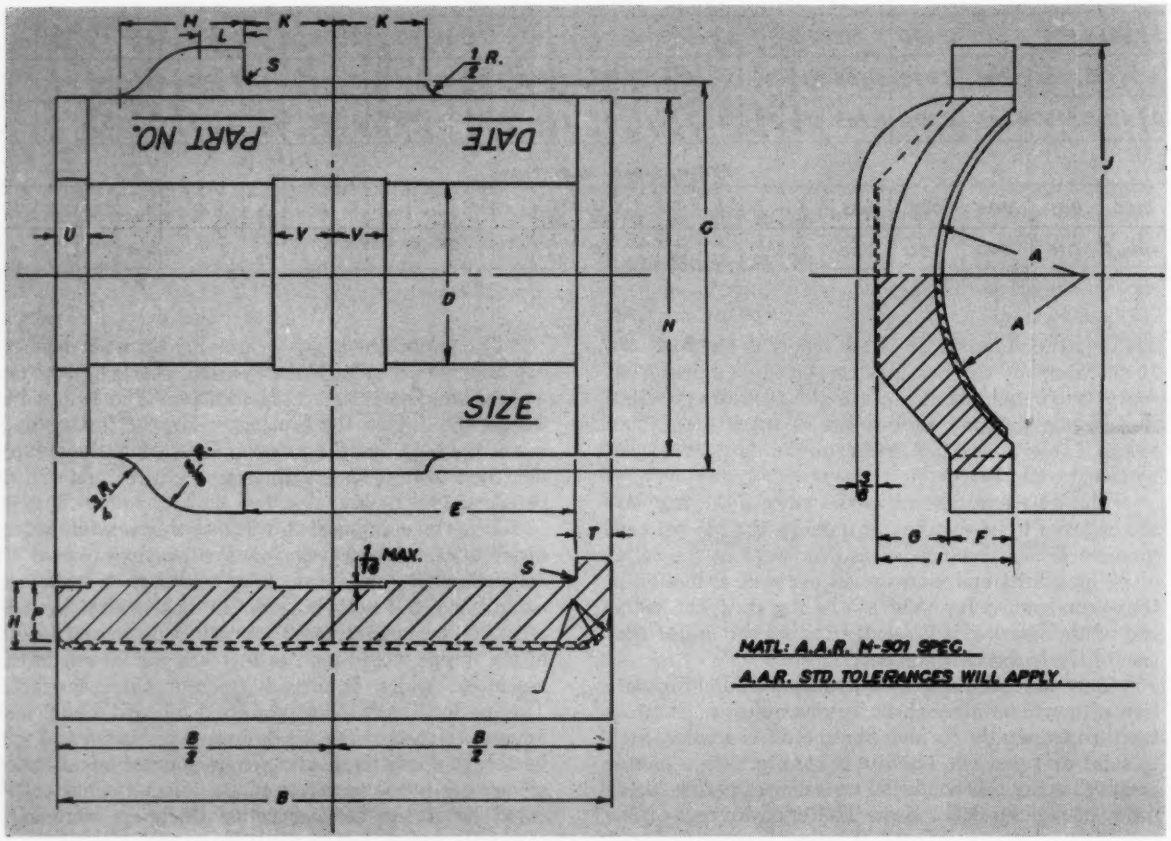

Fig. 3. Prewar AAR journal bearing with depressed back with permissible variations.

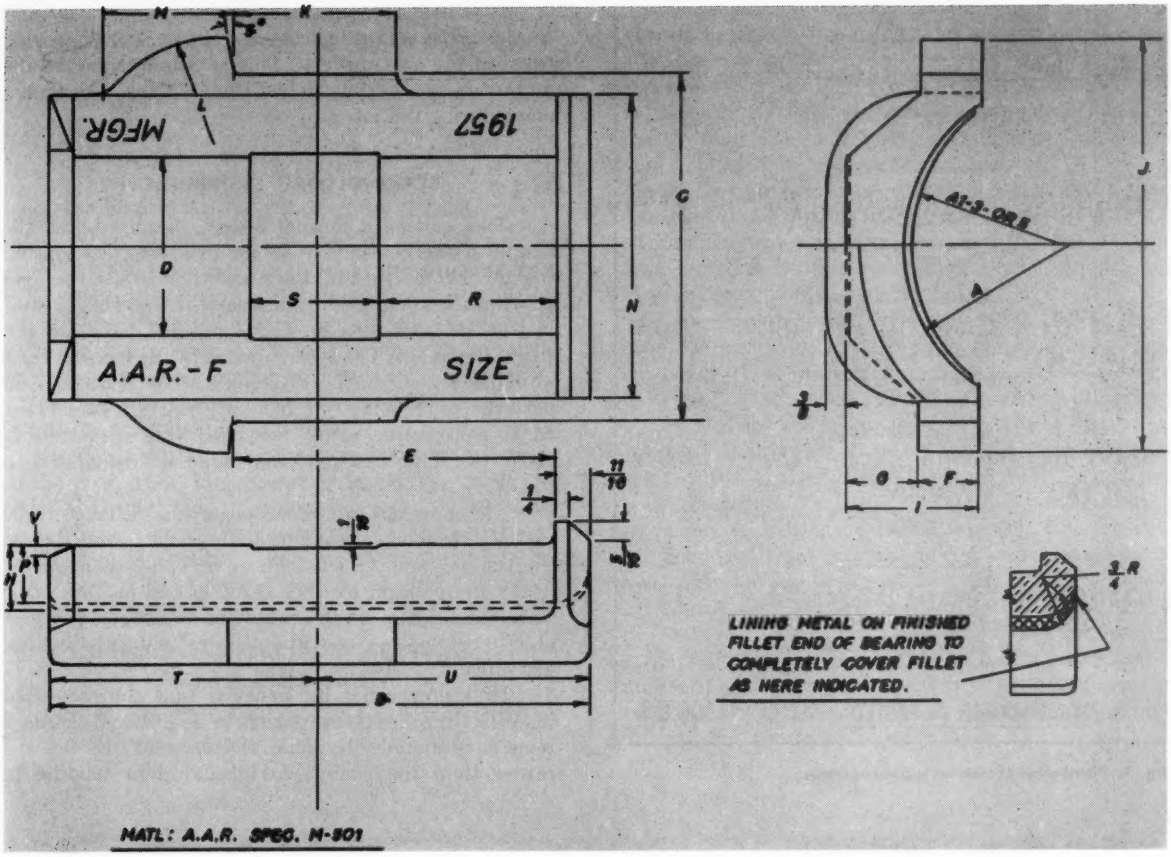

Fig. 4. AAR standard journal bearing with permissible variations per drawing D-24-1957.

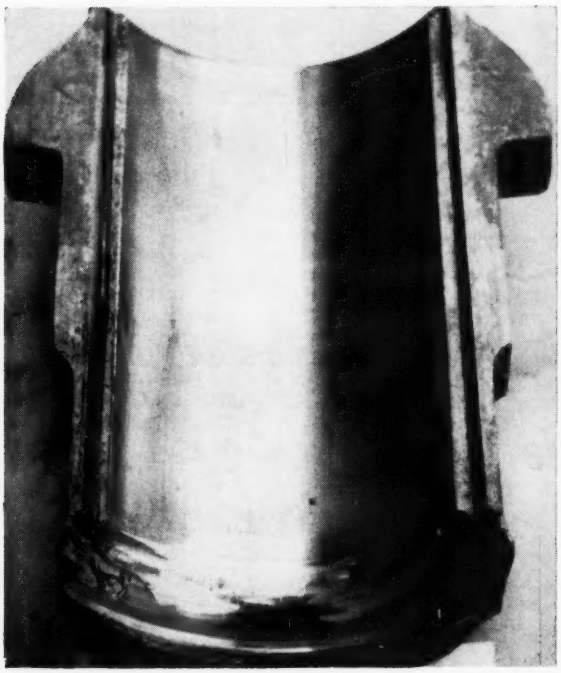

Fig. 5. Bearing showing ¾ inch fillet end wear.

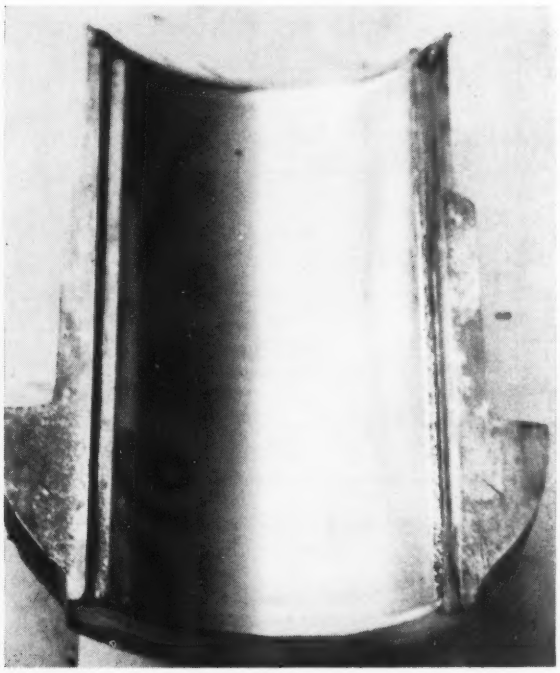

Fig. 6. Bearing showing lug end wear.

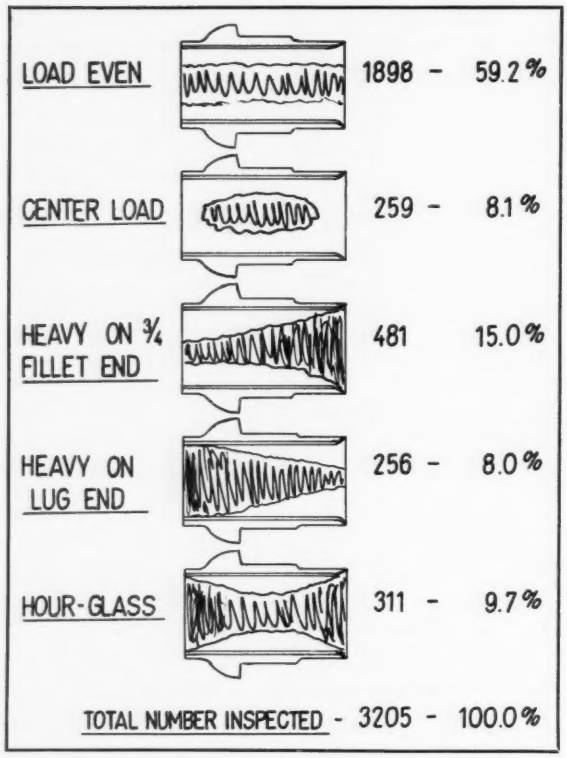

Fig. 7. Distribution of load on journal bearings.

It is also to be noted that lining wear has been eliminated as a cause for bearing removal in the period between the two surveys. This is possibly due to the improvement in journal finishing which has taken place during the interim.

BEARING LOAD DISTRIBUTION

The load on a journal bearing is distributed the length of the bearing by means of a crowned journal wedge. Several variables are known to effect the load distribution such as the thickness of the wedge, wear in the box roof, loss of wedge profile, and improper truck alignment. The configuration of the bearing back also has an effect. To determine what type of load patterns were being obtained by bearings in service, 3,205 consecutive scrap bearings were inspected in 1957. (3) The load patterns found are tabulated in Fig. 7.

The most desirable load pattern is believed to be that which shows a somewhat preferential loading at the center, and the least desirable those which show heavy preferential loading at either end or both ends, since the oil film at the center of the bearing is best able to carry the load without operating in the boundary range.

It is now generally believed that the depressed back bearing design as shown in Fig. 4 and Table 2 tend to preferentially load the ends of the bearing rather than the center. Additional data tending to

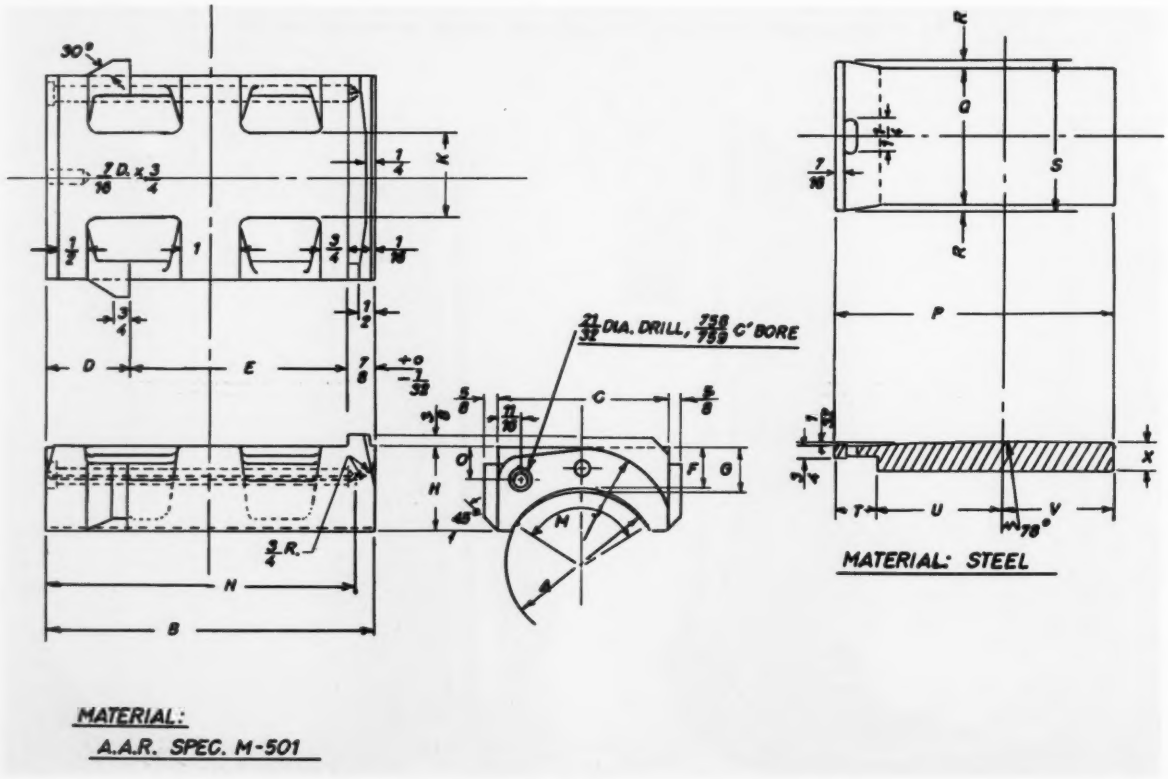

Fig. 8. Proposed flat back bearing and wedge.

confirm this opinion was developed by recently inspecting 1,002 consecutive bearings turned in for scrap, as follows:

570 Bearings—No evidence of wiping on corners.
224 Bearings—Wiping on corners at ¾ inch fillet end.
183 Bearings—Wiping on corners at lug end.
25 Bearings—Wiping on corners at both ends.

The AAR Research Department have this matter under active investigation and have laboratory tested bearing backs of other configurations. One design of a raised pad back bearing appeared sufficiently promising to be field service tested. The field test is now under way, but has not accumulated sufficient service data to warrant definite conclusions.

However, during the interim until the field testing can be completed, the recommendation was made to the AAR membership to eliminate the depressed back as an alternate and to revert to the straight back design used prior to 1942. This was submitted to letter ballot during 1958 and has become effective for mandatory use in 1959.

EXPERIMENTAL FLAT BACK BEARINGS RECENTLY FIELD TESTED

Figs. 8, 9 and 10, and Tables 4 and 5 show three experimental designs of bearings recently field tested, or presently undergoing field testing. Fig. 8 and Table 4 show a flat back bearing field tested on several railroads. It will be noted this bearing has a slightly greater bearing arc than the 120 degrees standard on the presently used steeple back bearings, and that the wedge is shortened sufficiently to compensate for the thicker collar.

The complete results of this field test have not been published, but it is believed that the overall performance was generally satisfactory. One report was received indicating more than a normal amount of lining breakage was experienced.

A bearing of quite similar design, but having provision for air ventilation through the back was also field tested. This bearing had cored passages through which cooling air passed, having entered the bearing by means of special neoprene rubber tubes so that air circulated within the bearing without entering the bottom portion of the box.

AAR Report No. MR-218 (4) gives detailed data concerning service performance for this bearing on tests conducted jointly by a railroad test department and the Mechanical Research Department of the Association of American Railroads.

The ventilated feature resulted in a reduction of bearing temperature below that obtained with a standard bearing of from 8 F to 30 F when other conditions such as type of packing, oil, and journal bearing mileage were approximately the same.

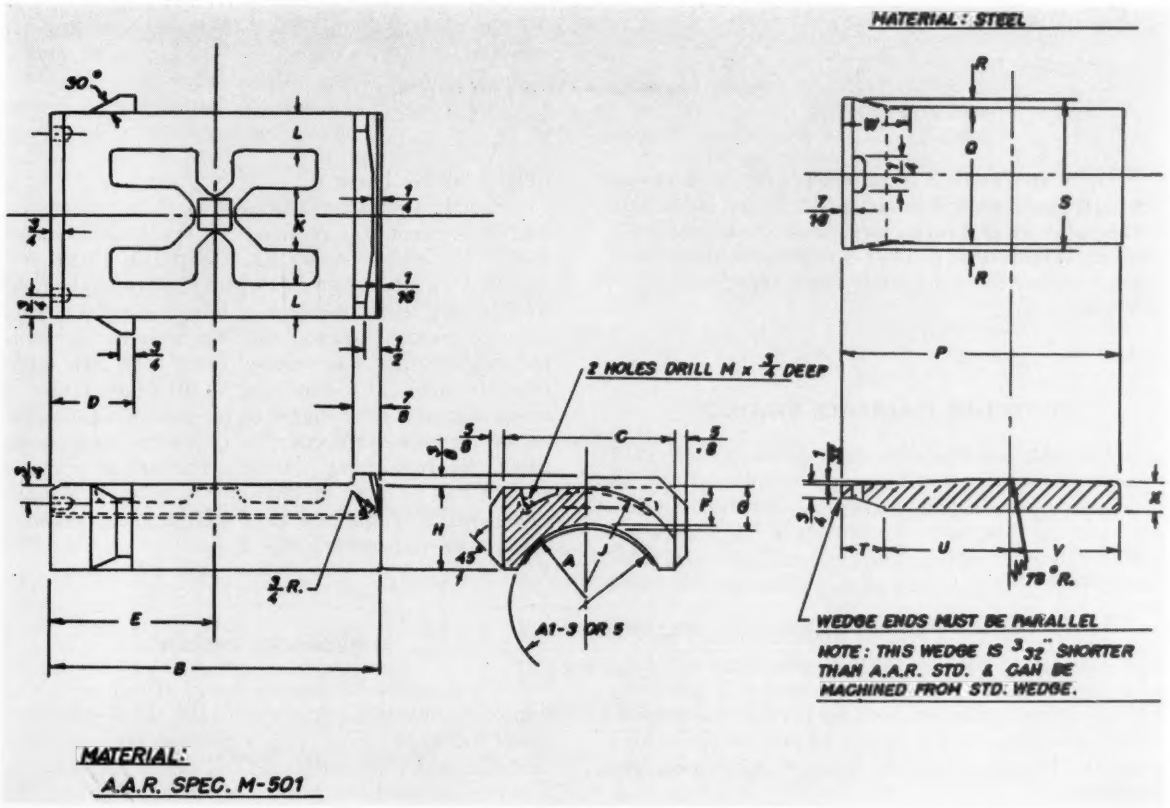

Fig. 9. Lateral control flat back bearing and wedge.

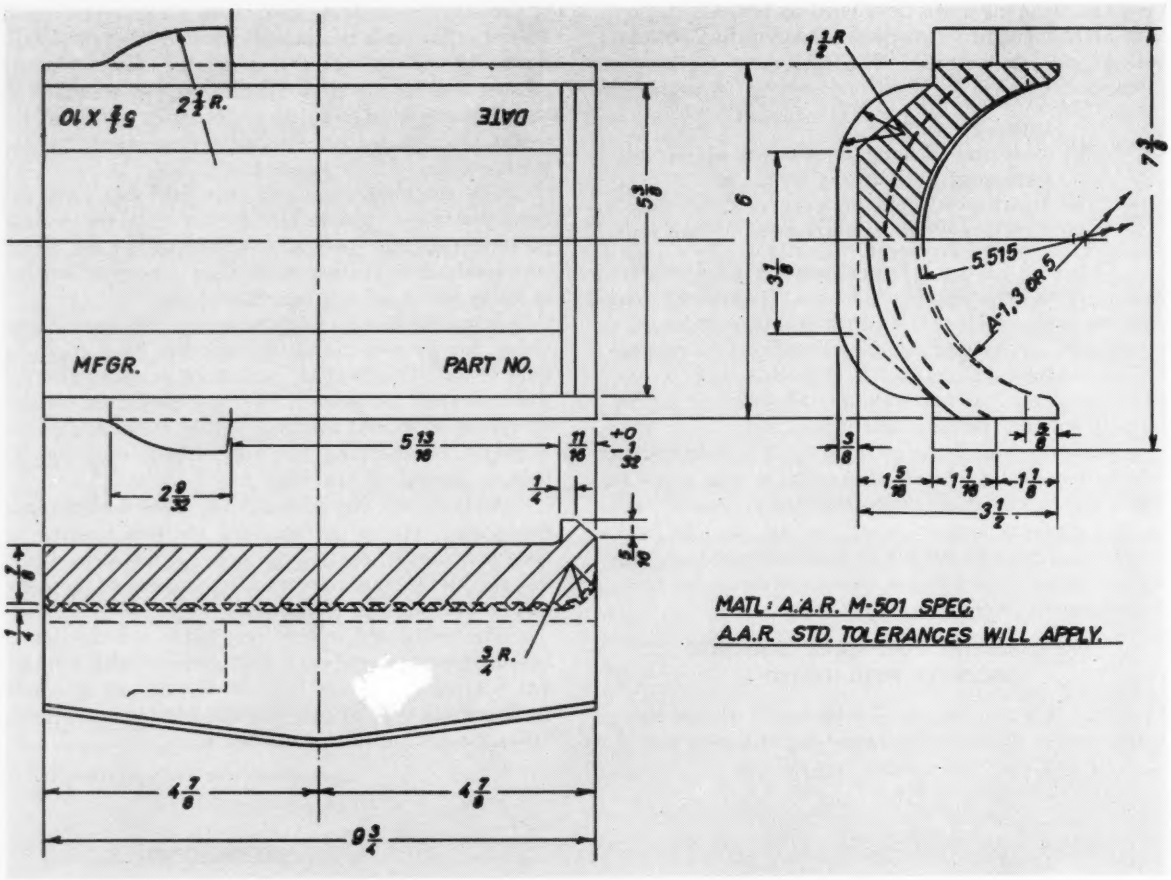

Fig. 10. Proposed journal bearing size 5-½ x 10.

Fig. 9 and Table 5 show another flat back design currently undergoing field testing. Limited road tests of this same design bearing were made during the AAR Clinton, Illinois tests in 1950. (5) None of these three designs have been adequately field tested to justify firm conclusions.

CONTROLLED CLEARANCE BEARINGS

The standard and customary practice until 1955 was to use a bearing with a nominal diameter 1/16 inch larger than the nominal journal diameter. An axle with journal diameters reduced up to ⅜ inch is acceptable for installation. A newly installed bearing and journal could have a difference in diameter of 7/16 inch.

This resulted in a critical break-in period for the new bearings applied to the undersized axles. Whenever the bearing was heavily loaded and until the bearing lining had accommodated itself to the journal, to the extent to give a 1-½ inch to two inch wide load zone, the bearing tended to operate under boundary conditions.

The undesirability of this condition was clearly pointed out in a research investigation of railroad freight car hot boxes (6).

Shortly thereafter a system for more closely fitting of bearings was proposed by the AAR Research Staff. The system known as "Controlled Clearance" was devised and offered. It provided for a nominal size, ⅛ inch undersize, and ¼ inch undersize bearing for each nominal journal size. The bore of the nominal size bearings was reduced from 1/16 inch larger than the nominal journal size to .015 inch larger. A series of gauges were suggested for measuring the axles in service, and more exacting tolerances were established for refinishing journals. The entire proposed system was adopted in 1955 and is believed to have, in general, accomplished what was intended—namely, a reduction in bearing break-in time.

A PROPOSED DESIGN

For a number of years a design of bearing having approximately 165 degree bearing arc has been used on street railways. It is also currently used on some switch locomotives and motor coaches. The greater the bearing arc tends to provide greater stability under impact and has an improved resistance to spread lining. This design bearing has been known to perform

TABLE 4. DIMENSIONS OF PROPOSED FLAT BACK BEARING AND WEDGE.

JRL. SIZE	DIMENSIONS OF BEARINGS														JRL. SIZE	DIMENSIONS OF WEDGES								
	A	B	C	D	E	F	G	H	J	K	L	M	N	O		P	Q	R	S	T	U	V	W	X
5 x 9	5 1/32	8 1/2	5 5/8	2 7/16	5 3/16	7/8	1 1/8	2 5/8	3 1/4	1 5/8	11/16	124°	7 3/4		5 x 9	8 9/16	5 5/8	9/16	6 3/4	1 3/8	3 11/16	3 1/2		1
5 1/2 x 10	5 17/32	9 1/2	6 1/8	2 15/16	5 11/16	7/8	1 1/8	2 5/8	3 1/2	1 3/4	11/16	120°	8 3/4	1 1/8	5 1/2 x 10	9 5/8	6 1/8	5/16	6 3/4	1 7/16	4 3/16	4		1
6 x 11	6 1/32	10 1/2	7 1/8	3	6 5/8	1	1 1/4	3 1/4	3 3/4	2	13/16	134°	8 3/4	1 1/2	6 x 11	10 5/8	7 1/8	5/16	7 3/4	1 7/16	4 11/16	4 1/2		1 1/8
6 1/2 x 12	6 17/32	11 1/2	7 5/8	3 1/2	7 1/8	1 1/8	1 3/8	3 5/8	4	2 1/2	15/16	138°	8 3/4		6 1/2 x 12	11 5/8	7 5/8	5/16	8 1/4	1 7/16	5 3/16	5		1 3/8
PERMISSIBLE VARIATIONS																								
PLUS		1/32	1/32	0	1/16	1/32	1/32	1/32					1/32			0	1/32							1/32
MINUS		1/32	1/32	1/16	1/32	1/32	1/32	1/32					0			1/32	1/32							1/16

satisfactorily under conditions of impact and braking so severe, standard AAR design bearings would regularly fail.

Fig. 10 details a design of such a bearing which, in the opinion of the author, is worthy of field evaluation in freight cars. It will be noted this bearing can be applied with the standard wedge and would require no changes in the journal box assembly. The lug location, length, and collar thickness are such as to provide the apparent optimum distribution of end thrust and lateral. Since over 20 per cent of all bearings are currently being scrapped for spread linings, the increased resistance to this defect should be welcome and result in a substantially longer bearing life. It also could be expected to reduce bearing displacement account of brake thrust and shock.

SUMMARY

The most significant bearing design changes for the solid bearing assembly have been reviewed and an attempt has been made to show the effect some of these design changes have had on service performance.

Attention has been called to the more recent experimental bearings undergoing field test and, finally, a design of bearing believed worthy of test evaluation has been proposed.

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3. Hanson, M. A., "Available and Potential Developments in Design for Standard AAR Solid Bearing Assemblies," ASME Paper No. 58-RR-3, April 1958, pp 1-3.
4. AAR Research Center—Report MR-218—"Journal Bearing Development Research and Journal Box Lubricating Materials," May 1954.
5. AAR Mechanical Research Report No. f 3000, "Investigation of Railway Equipment Journal Bearing Performance," pp 32 and 56.
6. Armour Research Foundation of Illinois Institute of Technology, "Railroad Freight Car Hot Boxes," v 1, pp 35-38.

TABLE 5. DIMENSIONS OF LATERAL CONTROL FLAT BACK BEARING AND WEDGE.

JRL. SIZE	DIMENSIONS OF BEARINGS															FIN. BRG. WT.	JRL. SIZE	DIMENSIONS OF WEDGES								
	A	B	C	D	E	F	G	H	J	K	L	M	A-1	A-3	A-5			P	Q	R	S	T	U	V	W	X
5 x 9	5 1/64	8 3/4	5 5/8	2 5/8	4 1/4	7/8	1 1/8	2 5/8	3 1/4	1 5/8	9/16	9/16	5.015	4.890	4.765	25 1/2	5 x 9	8 21/32	5 5/8	5/16	6 3/4	1 3/8	3 11/16	3 19/32	2 3/4	1
5 1/2 x 10	5 33/64	9 3/4	6 1/8	3 1/8	4 3/4	7/8	1 1/8	2 5/8	3 1/2	1 3/4	5/8	9/16	5.515	5.390	5.265	32 1/2	5 1/2 x 10	9 23/32	6 1/8	5/16	6 3/4	1 7/16	4 3/16	4 3/32	2 3/4	1
6 x 11	6 1/64	10 3/4	7 1/8	3 3/16	5 1/4	1	1 1/4	3 1/4	3 3/4	2	3/4	11/16	6.015	5.890	5.765	47 1/2	6 x 11	10 23/32	7 1/8	5/16	7 3/4	1 7/16	4 11/16	4 19/32	2 7/8	1 1/8
6 1/2 x 12	6 33/64	11 3/4	7 5/8	3 11/16	5 3/4	1 1/8	1 3/8	3 5/8	4	2 1/4	3/4	11/16	6.515	6.390	6.265	58	6 1/2 x 12	11 23/32	7 5/8	5/16	8 1/4	1 7/16	5 3/16	5 3/32	3 3/8	1 3/8
PERMISSIBLE VARIATIONS																										
PLUS	1/32	1/32	1/32	0		1/32	1/32						.005	.005	.005											
MINUS	1/64	1/32	1/32	1/16		1/32	1/32						.000	.000	.000											

Patent Abstracts

Compiled by Ann Burchick
Aluminum Co. of America

Tinning Oil Composition and Method of Using Same, Patent #2,886,465 (J. W. Nelson, assignor to Sinclair Refining Co.) In hot dip tinning operations wherein freshly tinned steel plate is contacted with a bath of a tinning oil maintained at an elevated temperature, the step of contacting the tinned steel plate with a tinning oil consisting essentially of a blend of palm oil and pentatriacontenyl succinic acid anhydride, said anhydride being blended in an amount sufficient to increase the dewetting characteristics of the palm oil in hot dip tin plating operations.

Clay Grease Compositions and Process of Preparation Therefor, Patent #2,886,524 (J. W. Armstrong and D. M. Preiss, assignors to Shell Development Co.) The process for the preparation of a high temperature grease composition which comprises: (a) forming a clay hydrogel; (b) adding thereto 20-200 per cent by weight, based on the clay, of aniline, whereupon aniline is adsorbed on the clay gel, water separates therefrom and is removed by mechanical separation; (c) displacing the water remaining in the gel with a water-soluble alcohol; (d) adding one-ten parts of a silicone oil of lubricating viscosity thereto, said amount being insufficient to form a cohered mass with the clay in the absence of alcohol; (e) heating the mixture in the presence of air at a temperature of 300-500 F. for 4-48 hours, whereby the alcohol is removed and aniline is oxidized on the gel surface; (f) adding to the heat treated product an amount of silicone oil sufficient to form a grease structure therewith.

Method of Grease Manufacture which Comprises Shearing the Grease Mixture at High Temperatures, Patent #2,886,525 (J. P. Dilworth, T. B. Jordan and B. L. Benge, assignors to The Texas Co.) The method of preparing a lubricating grease which comprises providing a molten homogeneous mixture of a soap and an oleaginous liquid in grease forming proportions at an elevated temperature above the solution temperature but below the decomposition temperature of the soap, maintaining a body of relatively large volume of the said mixture with agitation while cooling it at a rate below 25 F per minute until a grease consistency is obtained, and subjecting the said mixture to a shearing action at a temperature in the transition temperature range by continuously withdrawing a recycle stream of relatively small volume from the maintained body of the mixture, passing it under pressure through a restricted orifice into a confined passageway, with a pressure drop of about 10-200 pounds per square inch across said orifice, and then returning it to the said maintained body of the mixture at a batch turnover rate of at least about 0.13 per minute until the volume of the recycled mixture is at least equal to the total volume of the said mixture.

EP Additive for Mixed Lithium-Calcium Base Greases, Patent #2,886,526 (J. R. Roach and J. P. Dilworth, assignors to The Texas Co.) A grease characterized by EP properties comprising an oleaginous lubricating base as the major component, a mixed lithium-calcium base comprising 10-90 parts lithium soap and 90-10 parts calcium soap in an amount sufficient to thicken said lubricating base to grease consistency, said soap mixture being derived from an acidic mixture comprising a minor portion of a fatty acid-containing material and a major portion of a hydroxy fatty acid-containing material, two to five per cent trialkyl phosphite in which the alkyl group contains three to ten carbon atoms and 0.5 to 2.5 percent dialkyl selenide in which the alkyl group contains eight to eighteen carbon atoms, said phosphite-selenide mixture imparting EP properties to said mixed lithium-calcium base grease.

Diester Lubricant, Patent #2,886,590 (C. W. Montgomery, W. I. Gilbert and J. G. McNulty, assignor to Gulf Research & Development Co.) The diester of isoamyl alcohol and 3, 6, 9,-trioxa-1, 11-undecanedioic acid.

Motor Lubricating Oil Composition, Patent #2,887,452 (N. Alpert, S. R. Newman and R. Y. Heisler, assignors to The Texas Co.) A lubricating oil containing a minor amount of an amine carboxylate in an amount sufficient to improve the cleanliness properties of the lubricant composition.

Stabilization of Hydrocarbon Oil Heavier than Gasoline, Patent #2,888,337 (J. A. Chenicek, assignor, by mesne assignments, to Universal Oil Products Co.) Hydrocarbon oil heavier than gasoline normally subject to deterioration in storage containing, in sufficient amount to retard said deterioration, a 1, 3-diazine having an amino substituent attached to the two carbon atom, said diazine consisting of carbon, hydrogen and nitrogen.

Rust Inhibited Stabilized Hydrocarbon Fuel Oil, Patent #2,888,338 (F. B. Fischl, J. V. Clarke, Jr. and J. O. Smith, Jr., assignors to Esso Research & Engineering Co.) A fuel oil composition consisting of amajor proportion of hydrocarbons boiling in the fuel oil boiling range and a minor proportion of a mixture of an alkaline earth metal salt of an alkyl phenol sulfide, in which the alkyl group has from five to 18 carbon atoms and the alkaline earth metal is selected from the group consisting of calcium and barium, with a complex prepared by the reaction of: from five to ten parts of an alkylated benzene sulfonic acid having from five to 30 carbon atoms in the alkyl group; from one to six parts of an alkali metal nitrite; and from one to three parts of a highly basic heterocyclic nitrogen compound selected from the group consisting of morpholine and hydroquinolines; said reaction producing said complex being conducted at a temperature and for a period of time sufficient to remove all of the water from said complex; the ratio of alkaline earth metal salt to complex being in the range of from three to one to one to three, said mixture being present in an amount not more than about 0.2 per cent but sufficient to inhibit the formation of sediment in said fuel oil.

Sulfonate and Sulfo-Carboxylate Containing Sodium Base Grease, Patent #2,889,280 (L. U. Franklin and J. C. Gebhart, assignors to Gulf Oil Corp.) A grease composition comprising a dispersion of about 0.5 to about 5.0 per cent by weight of a metal salt of an oil-soluble petroleum sulfonic acid, about 0.1 to about 1.0 per cent by weight of a metal salt of a sulfonated monocarboxylic acid having about 12 to about 22 carbon atoms and a sulfur content of about 0.5 to about 3.0 per cent by weight based on the weight of said metal salt of the sulfonated monocarboxylic acid, and a sodium soap of a fatty acid having about 12 to about 22 carbon atoms in an amount sufficient to produce a composition having the consistency of a grease in a major amount of a mineral oil.

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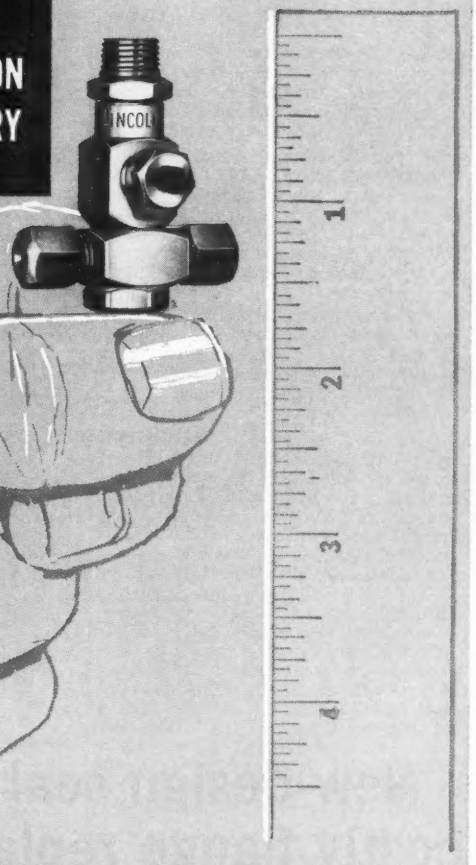

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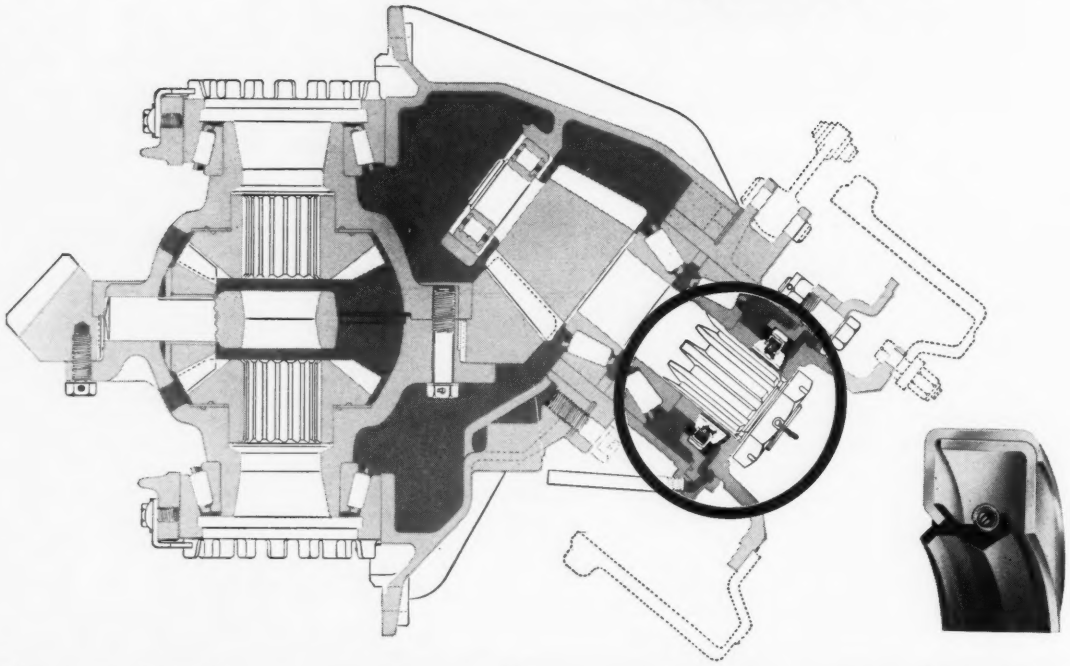

New design seal ends grooving, eliminates costly flange replacement on bus axle carrier

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The results of extensive testing at the Bavarian Testing Institute at Nurenberg showed it to be more economical to move this bridge on girders lubricated with MOLYKOTE Type G than on rollers.

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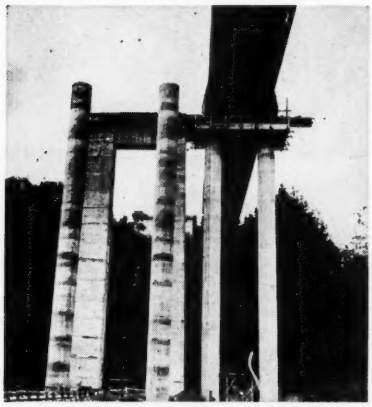

This bridge carries traffic of the Munich-Salzburg Highway over the Mangfall Valley.

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NEW MOLYKOTE "WEAR IN" COMPOUND REDUCES SURFACE DAMAGE RESEARCH PROVES

During the critical wear in period, permanent surface damage, variously described as "galling", "scuffing", "scoring", "tearing", "scratching", "excessive abrasion", and "seizing", is an inherent hazard.

Cross section of ground steel surface. (Redrawn to scale.)

When magnified, even highly polished metals show surface irregularities as in the drawing above.

MOLYKOTE "Wear In" Compound was developed as a result of extensive research. It drastically reduces the time necessary to accomplish wear in and eliminates the hazards.

"Wear In" damage requires costly reconditioning of new equipment and the amount of damage left unrepaired has much to do with the useful service life of machinery.

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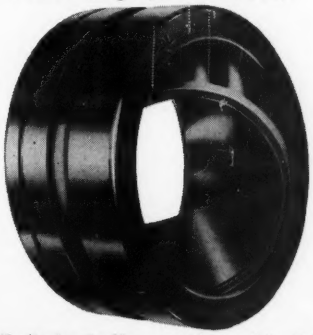

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LUBRICATION IN THE NEWS

(*Cont. from p. 422*)

no rights in establishing fair trade prices for the independents, and it is our observation that they are not making much of an attempt to enforce fair trade."

Fair trade has a doubtful legal status, he said. The Department of Justice and the Federal Trade Commission are opposed to it. One company tried fair trade on some appliances for five years, instituted 3,000 cases and were reported to be spending a million dollars a year trying to enforce it before they gave it up.

Attempts to enforce fair trade can wreck good relationships between supplier and dealer, he told the marketers. "The minute you file a suit you destroy a relationship of trust, confidence and cooperation that you have developed over a period of years."

It is hard to get evidence of violations and even harder to get favorable judgments in court. Attempts to circumvent fair trade are increasingly common.

Even in areas where fair trade is apparently working, the prospects for long term success are doubtful. In New Jersey, the number of independents has risen from 165 to nearly 600 since fair trade was re-instituted in 1956. The independents sell three times as much gasoline as they did before fair trade was restored, and they are increasing their share of the market. "You can make your own predictions as to the next sequence of events," Jordan told the Ohio Marketers.

He listed three alternatives to fair trade:

1. Follow the present prevailing practice, with dealers and jobbers free to set their own prices.

2. Get government control over all levels of pricing. He strongly opposes this.

3. Urge every marketer to ask himself "Am I part of the problem or part of the answer?" and then make any changes appropriate to the health of the industry.

The free market system may not be perfect, but it has provided more people with more things than ony other in history. Any attempt to tamper with it by restricting freedom of pricing would injure rather than improve.

PERSONALS

(*Cont. from p. 428*)

nounced by SKF Industries, Inc. In his new post with the Philadelphia ball and roller bearing manufacturer, Lofton will coordinate efforts of the field sales force on railway accounts, which include the sale of railway journal boxes and bearings.

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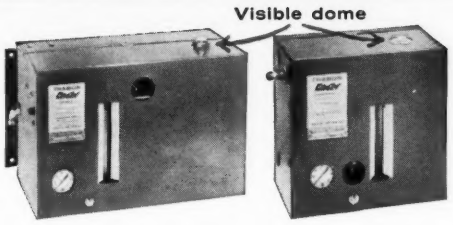
CENTRALIZED LUBRICATING SYSTEMS

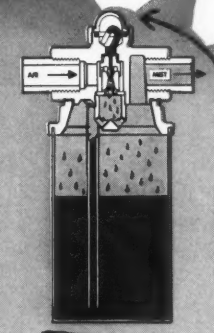
...packages with a plus!



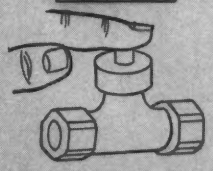
Meter-Mist units are available in 12 package sizes to fit every job.

Meter-Mist oil systems give you all these extras— at low cost

- Neat, compact lubricator units with all components housed in tamper-proof lock-cover
- Reservoir sizes up to 3 gallons—enough for 200 hours or more without refilling
- Misting-head capacities to handle up to 1000 bearing-inches without "manifolding"
- Complete visual indication of (1) oil feed, (2) air pressure and (3) reservoir level with cover closed and locked
- Pre-wired, with all wiring run to terminal strip
- Pre-piped, ready for air and outlet connections
- Remote mist indication at bearing tap
- Automatic controls and fool-proof warning signals



Visible oil feed dome provides a quick means of checking oil flow.



Finger tip pressure on pin of special flow indicator fittings located at remote bearings quickly checks mist condition at that spot.

Trabon Meter-Mist, the modern inexpensive lubricating method *for all types of bearings, slides and gears,* gives you the "extras" you want *in packaged form* when a centralized oil-fog system is indicated. Adopted by industry for machine tools, presses and even rolling mill lubrication, Meter-Mist systems transmit micron-sized particles of oil, formed at the misting-head, in the form of a dry mist to bearing areas via low pressure air. There, reclassifier fittings cause the mist to wet-out on the bearing or gear surface.

For more information about Meter-Mist and its 12 packaged models write for Meter-Mist Bulletin 659.

Trabon®

"Centralized" OIL AND GREASE SYSTEMS "Meterflo" CIRCULATING OIL SYSTEMS

Trabon Engineering Corporation 28787 Aurora Road • Solon, Ohio

NONSEPARA

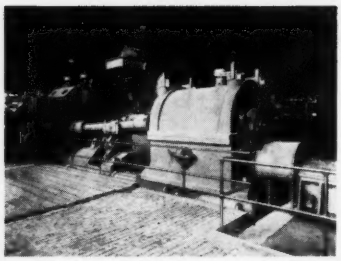
A STABILIZED GREASE MEETING N.L.G.I. CLASSIFICATION

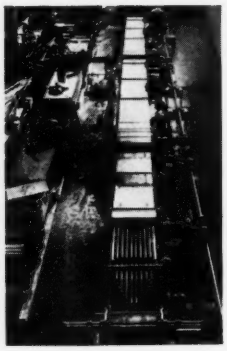
NONSEPARA is a stabilized, non-separating, lime base grease compounded with high titre prime tallow and blended with various filtered mineral and paraffin oils to comply with N.L.G.I. classifications.

NONSEPARA possesses water resistant and adhesive-cohesive qualities unequalled in retention over any other similar lubricant. NONSEPARA is not a mixed base. Through the use of exclusive production techniques and special equipment, it is shipped in a worked consistency for immediate use.

Recommended for spring loaded reservoirs, grease cups, guns and other mechanical lubricating devices. May be forced through restricted orifices and long lines without separating or obstructing passages.

NONSEPARA has a record of notable installations under varied climatic conditions and ambient temperatures of widely scattered industrial fields.





CASE HISTORIES:

Strip cleaner, all bearings, line shafting and rolls.
NONSEPARA installed 1937

Entire can plant.
NONSEPARA installed 1940

Ore dock and bridges.
NONSEPARA installed 1932

High speed printing presses.
NONSEPARA installed 1938

NONSEPARA is a registered trade mark of
The Hodson Corporation

The HODSON CORPORATION
Lubrication
5301-11 WEST 66TH STREET
CHICAGO 38, ILLINOIS

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